

1964

Potassium in Soils Planted to Sugar Cane and Response to Fertilizer Potassium.

Ray Ricaud

Louisiana State University and Agricultural & Mechanical College

Follow this and additional works at: https://digitalcommons.lsu.edu/gradschool_disstheses

Recommended Citation

Ricaud, Ray, "Potassium in Soils Planted to Sugar Cane and Response to Fertilizer Potassium." (1964). *LSU Historical Dissertations and Theses*. 997.

https://digitalcommons.lsu.edu/gradschool_disstheses/997

This Dissertation is brought to you for free and open access by the Graduate School at LSU Digital Commons. It has been accepted for inclusion in LSU Historical Dissertations and Theses by an authorized administrator of LSU Digital Commons. For more information, please contact gradetd@lsu.edu.

This dissertation has been 65-3396
microfilmed exactly as received

RICAUD, Ray, 1930-
POTASSIUM IN SOILS PLANTED TO SUGAR
CANE AND RESPONSE TO FERTILIZER
POTASSIUM.

Louisiana State University, Ph.D., 1964
Agriculture, plant culture

University Microfilms, Inc., Ann Arbor, Michigan

**POTASSIUM IN SOILS PLANTED TO SUGAR CANE
AND RESPONSE TO FERTILIZER POTASSIUM**

A Dissertation

**Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy**

in

The Department of Agronomy

by

Ray Ricaud

B.S., Louisiana State University, 1953

M.S., Louisiana State University, 1957

August, 1964

ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to Dr. M. B. Sturgis, Head of the Department of Agronomy, who directed this investigation and gave constructive criticism during the course of this study and in the preparation of the manuscript. He also wishes to thank Mr. D. S. Byrnside, Jr. and Dr. L. E. Golden for obtaining some of the yield data used in this study. Thanks are given to owners and managers of the sugar cane plantations who made available the necessary land, equipment, labor and mill facilities in conducting the fertilizer experiments.

The writer expresses his appreciation to his wife, Joyce for typing the manuscript and to his children, Reba and John for their patience during the course of this study.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENT	11
LIST OF TABLES	iv
LIST OF FIGURES.	vii
ABSTRACT	viii
INTRODUCTION	1
REVIEW OF LITERATURE	4
MATERIALS AND METHODS	23
EXPERIMENTAL RESULTS AND DISCUSSION	32
Chemical and Physical Properties of Soils	32
Sugar Cane Yield in Fertilizer Experiments.	53
Response of Sugar Cane to Fertilizer Potassium.	62
Uptake of Potassium by Sugar Cane	71
Rainfall and Yield of Sugar Cane	81
General Discussion	90
SUMMARY AND CONCLUSIONS	93
BIBLIOGRAPHY	95
AUTOBIOGRAPHY.	105

LIST OF TABLES

Table	Page
1. Soil types and location of experiments with fertilizers for sugar cane on Alluvial soils and Older Alluvial or Terrace soils	33
2. Potassium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction	34
3. Calcium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction	35
4. Magnesium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction	36
5. Sodium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction	37
6. Exchange properties in milli-equivalents per 100 grams of dry soil and pH values of Alluvial soils and Older Alluvial or Terrace soils	38
7. Clay, organic matter, total nitrogen and available phosphorus contents of Alluvial soils and Older Alluvial soils or Terrace soils	39
8. Relationship between available, exchangeable and total potassium contents of Alluvial soils and Older Alluvial or Terrace soils	40
9. Simple correlation coefficients showing the relationships between some of the chemical and physical properties of the soils studied	41
10. Effect of fertilizers on yield of plant and stubble sugar cane in tons per acre in experiments conducted from 1954 to 1960	54

Table	Page
11. Effect of fertilizers on yield of plant and stubble sugar cane in tons per acre in experiments conducted from 1960 to 1963	58
12. Analyses of variance for yield data of sugar cane, stubble C. P. 52-68, on Mhoon silt loam at Little Texas Plantation in 1961	61
13. Sugar cane yield responses due to fertilizer potassium on Alluvial soils by the factorial and comparative methods of analysis	63
14. Sugar cane yield responses due to fertilizer potassium on Older Alluvial or Terrace soils by the factorial and comparative methods of analysis	65
15. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, 1st stubble C. P. 52-68, on Mhoon silt loam at Little Texas Plantation in 1961	74
16. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, plant C. P. 52-68, on Commerce silt loam at Alma Plantation in 1962	75
17. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, 1st stubble C. P. 52-68, on Cypressmort silt loam at Alice "B" Plantation in 1961	76
18. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, plant N. Co. 310, on Baldwin silt loam at Alice "B" Plantation in 1962	77
19. Analysis of variance for potassium uptake by millable sugar cane, 1st stubble C. P. 52-68, on Mhoon silt loam at Little Texas Plantation in 1961	78
20. F values for each source of variation in yield, per cent of sucrose and potassium uptake of sugar cane calculated in analyses of variance for combined experiments for the four experimental locations	82

Table	Page
21. Precipitation in inches of rainfall at experimental locations	83
22. Simple correlation coefficients showing the relationship between rainfall during different periods and sugar cane yield in fertilizer experiments	88

LIST OF FIGURES

Figure	Page
1. Relationship between exchangeable K and available K extracted with 0.1 N HCl at 1:20 soil to solution ratio	43
2. Relationship between exchangeable K and clay contents of the soils	45
3. Relationship between exchangeable K and total K contents of the soils	46
4. Relationship between clay and organic matter contents of the soils	52
5. Relationship between response to K_2O and available K extracted with 0.1 N HCl at 1:20 soil to solution ratio	70
6. Deficiency symptoms in sugar cane	72
7. Potassium deficiency symptom in sugar cane	73

ABSTRACT

A study was made of the soils in the sugar cane area of Louisiana which involved the Alluvial soils of the lower Mississippi and Red River flood plains and Older Alluvial or Terrace soils bordering Bayou Teche. The objectives were to determine the total soil potassium, exchangeable cations, other properties of the soils, the uptake of potassium and rainfall as related to yield and response of sugar cane to fertilizer potassium.

Forty-nine fertilizer experiments were conducted at 28 locations on 16 soil types by the Agronomy Department of the Louisiana Agricultural Experiment Station from 1954 to 1963. Treatments in each fertilizer experiment consisted of combinations of three rates of N, two rates of P and two rates of K placed in a randomized block design with three replications.

Available or extractable cations of the soil were extracted with 0.1 N hydrochloric acid and 1.0 N ammonium acetate at 1:10 and 1:20 soil to solution ratios. The 1.0 N ammonium acetate solution extracted more potassium from the soils than the 0.1 N hydrochloric acid solution. More of the soil cations were extracted at a 1:20 than at a 1:10 soil to solution ratio with either extractant. Potassium extracted by the methods studied was generally higher in the Alluvial soils than in the Older Alluvial or Terrace soils. Although the available or 0.1 N hydrochloric acid extractable potassium was slightly

lower in amounts, it was highly associated with the exchangeable potassium. Available potassium was not highly associated with total soil potassium but it was highly correlated with clay content and to a lesser degree with organic matter content of the soil.

Results from a factorial analysis of the yield data of sugar cane revealed that the response to fertilizer potassium was significant in 4 experiments on Alluvial soils with a maximum response of 1.9 tons per acre. The yield response was significant in 10 experiments on Older Alluvial or Terrace soils with a maximum response of 3.3 tons per acre.

Results from a comparative analysis of the yield data of sugar cane revealed that the maximum yield response obtained to fertilizer potassium was 3.3 tons per acre on the Alluvial soils and 3.8 tons per acre on the Older Alluvial or Terrace soils. The relationship between available soil potassium and response of sugar cane to fertilizer potassium as determined by the comparative method of analysis was significant. The regression equation for this relationship shows that a profitable response of more than one ton per acre was obtained on soils which contained less than 120 ppm. of available potassium. Greater responses were obtained with stubble cane than with plant cane.

As an average of the 4 locations studied, the potassium uptake per ton of millable sugar cane was 2.38 pounds as K_2O in the millable cane and 5.27 pounds as K_2O in the total above-ground growth. The millable cane contained 45.2 per cent of the potassium in the total above-ground growth.

Simple correlation coefficients between rainfall during different periods of the year and yield of sugar cane revealed that in many cases studied a lower rainfall was associated with an increase in yield. This effect was more pronounced on Older Alluvial or Terrace than on Alluvial soils and more pronounced with stubble than with plant sugar cane.

INTRODUCTION

Although Van Helmont in the early seventeenth century regarded water as the sole nutrient for plants, farmers had been using potassium unconsciously for many years before that time in the form of animal manures and wood ashes to increase the fertility of the land. It was not until 1840 that the necessity and importance of potassium for the growth of plants were fully established by the chemist Liebig. Since that time considerable progress has been made in developing field and laboratory techniques for determining the availability and requirement of potassium for the growth of plants.

Potassium in soil exists in different forms. Some forms are soluble in water. Some forms are insoluble even in strong acids, and others are of intermediate solubility. Most of the soil potassium is not available to plants even after years of cropping. A large proportion of it, approximately 99.5 per cent, is in primary potassium bearing minerals in the silt and sand fractions of soil. These minerals include mainly two micas (muscovite and biotite) and two feldspars (orthoclase and microcline). Clay minerals such as montmorillonite, kaolinite, illite and other hydrous micas and soil organic matter contain exchangeable potassium which is the important reservoir of readily available potassium in the soil. Soluble potassium that is free to move with the soil water amounts to a small fraction of the exchangeable quantity. The soluble and exchangeable forms are in equilibrium

with each other. A reduction of the soluble forms by crop removal or leaching is followed instantly by a transfer from the exchangeable forms so as to maintain equilibrium. When a soluble fertilizer potassium salt is added to the soil, a transfer occurs from solution to exchange surfaces. Another equilibrium exists between the more easily exchangeable and the potassium within the clay lattice, but this equilibrium is more sluggish than that between soluble and exchangeable forms (72, 106).

For the past half century, soil scientists have attempted to treat the soil with various chemical agents to extract some fraction of the total supply of potassium in the soil that is equal or at least proportional to the amount of potassium that a crop can utilize during its growing season. An ideal extracting solution for available or extractable soil potassium has never been found.

As empirical as an extraction method for assessing soil fertility may be, it may provide nevertheless, one of the most useful means for ascertaining the most profitable returns from fertilizers. Its successful use, however, depends to a large degree upon careful calibration of the results of the chemical test with responses of different crops to application of fertilizers on different soil types (97).

A study of the responses of sugar cane to the application of fertilizers has been in progress in Louisiana for 25 years. Of the three major plant food nutrient elements, potassium has received the least attention. Since the field experiments on fertilizers for sugar cane provide a means for calibrating field responses to fertilizer and soil potassium, this study was begun. The primary objectives were

to determine, (1) total soil potassium, available and exchangeable soil cations and other properties of the soils, (2) yield and response of sugar cane to fertilizer potassium, (3) relationship between soil potassium and response of sugar cane to fertilizer potassium, (4) uptake of potassium by sugar cane, and (5) relationship between rainfall and yield of sugar cane.

REVIEW OF LITERATURE

Potassium has been included in the list of essential elements for plant growth since the early nineteenth century. Since that time, attention has been focused upon the role of potassium in plants, but its exact function has not been definitely determined. A general conception presently held by many investigators is that potassium affects several vital processes in living plants.

Hartt (52) reported that potassium was a specific activator of the enzyme invertase in the synthesis of sucrose in sugar cane plants. Hartt (53) later found an accumulation of amino nitrogen with a decrease in protein nitrogen which indicated that the potassium deficient plants were unable to synthesize protein as usual. Richards and Berner (107) working on the nutrition of barley recently reported that accumulation of free amino acids associated with potassium deficiency was due to increased respiration rates in plants. Gruneberg (49) found that potassium was associated with high energy transformations in plants and played an important role as a catalyst in the metabolism of plants.

Lawton and Cook (75) listed some of the vital processes in living plants affected by potassium as, (1) synthesis of simple sugars and starch, (2) translocation of carbohydrates, (3) reduction of nitrates and synthesis of proteins, particularly in meristem tissues, and (4) normal cell division. Barber and Humbert (10) have added stomatal

movement and water relationship to the list of vital processes affected by potassium.

Absorption of Potassium by Plants

Absorption of mineral elements by plants grown in soil involves various chemical and physiological processes outside and within the plant roots which are not well understood. Some workers believe that the entry of cations into an ionic double layer associated with root surfaces and cell walls is the first step in ion accumulation by plant roots. In a recent study of ion uptake by living plant roots, Walker and Barber (137) showed that rubidium⁸⁶ absorption occurred initially through the root tips and subsequent absorption continued all along the root surface.

Jenny and Overstreet (70) proposed the concept of contact exchange between colloidal clay and plant root surfaces as a means of cation absorption. According to their concept, plant roots may be able to absorb exchangeable potassium directly from the solid mineral particles of the soil by excreting hydrogen ions from their surface which replace some of the adsorbed cations on the clay. These hydrogen ions come in part from the carbonic acid liberated by the roots during respiration and in part by diffusion through a cell membrane, as in Lundegardh's (82) theory of nutrient uptake. His theory is based on the aerobic oxidation of carbohydrates in the absorbing cells. The source of electrons inside the cells is hydrogen atoms which become hydrogen ions and are concentrated during the oxidation of carbohydrates. Due to this increased concentration of hydrogen ions inside the cells, cations from the soil solution are exchanged for hydrogen ions inside the cells.

Numerous workers (55, 81, 96, 102, 109) have studied factors affecting the absorption of potassium by plants. It is generally agreed that due to antagonism between ions, a low or medium concentration of one ion in the soil may be depressed to the point of deficiency by another ion present in higher concentration. The balance and activity of ions are important as well as the actual amounts. Lundegardh (81) found that the potassium ion, due to its high mobility, was able to overcome a concentration deficit by depressing less mobile ions.

Potassium absorption by sugar cane may be markedly affected by the variety grown as well as the soil type involved. Brown (22) reported that five varieties of sugar cane seedlings grown on four different Florida soils absorbed widely different quantities of potassium depending on the soil involved. Hammond et al. (51) and Humbert (64) showed that potassium deficiency in plants grown on heavy clay soils which were well supplied with exchangeable potassium was due to the slow rate of gas exchange which caused the level of oxygen to drop below that required for effective absorption of potassium. Bear (14) pointed out that at equal levels of exchangeable soil potassium plants obtained relatively more exchangeable potassium from soils with lower bonding energy for potassium.

Fixation and Release of Potassium in Soil

Fixation of soluble soil potassium to less available forms has been the concern of many workers. Page and Bayer (94) pointed out that potassium fixation in soil was due to the trapping of potassium ions within the crystalline lattice structure of clays. Joffe and

Kolodny (71) suggested that soluble potassium was combined with iron and phosphate to form an insoluble potassium iron phosphate. An explanation of the fixation of potassium made by Volk (133) was that exchangeable potassium reacted with colloidal silicates to form difficult soluble muscovite. Gorbunov (47) suggested that the aging of the soil gels due to drying was responsible for the fixation of potassium. He believed that drying of soil decreased or destroyed the diffusion layer of exchangeable cations, and potassium was thus transferred to the inner surfaces of the colloidal particles. Because of the destruction of the outside diffusion layer the particles became electrically neutral and the electrokinetic potential dropped, thereby fixing the potassium.

Release of potassium from non-exchangeable forms has been studied by several workers (8, 20, 43, 55, 123, 127). These workers generally agree that the non-exchangeable potassium is important in assessing the ability of a soil to supply potassium for plant growth.

Walker (138) working with soils in Louisiana concluded that potassium applied as muriate of potash was not strongly fixed so long as optimum moisture was maintained in the soil. He found that over 40 per cent of the added potassium was soluble in water after a period of six months. Additions of organic matter to the soil not only prevented the fixation of applied potassium, but changed from non-exchangeable to exchangeable form more than 70 ppm. of native potassium. Air drying the soil resulted in the fixation of 28 per cent or more of the potassium added. Heating the soil to 105° C. caused the fixation of 45 per cent of the potassium which formerly was exchangeable.

Worsham and Sturgis (140) studied the characteristics of 14 soil types of the lower Mississippi delta in relation to available potassium and the fixation of potassium in the soils. They reported that a wide variation in the availability of the native potassium in the soils was found to exist. In general, a high available potassium content was associated with a high base exchange capacity. An increase in base saturation was associated with an increase in fixation until near complete base saturation was reached, after which there was a decrease in the fixation of potassium.

Evaluation of Available Soil Potassium

Availability of soil potassium to plants is determined by the various factors that affect absorption of the element by plants. In a true sense, the plant is the only agent that can determine the amount available. However, it is practically impossible to test the soil of all farmers by crop response. It also is not always possible to apply the results of a field test on one farm to fields or farms in the same general area. In order to extend the usefulness of field tests, scientists have developed chemical tests of soils to determine fertilizer needs. When these tests are properly calibrated against yield responses from field results, they may serve as a basis for fertilizer recommendations. Many workers have devoted their efforts to the evaluation of various chemical methods for the determination of available soil potassium (41).

It is within the scope of this study to review only briefly some of the work on soil testing methods. Spurway (121) found that chemical tests were the best known means for a rapid diagnosis of the condition

of soils with respect to their content of soluble constituents which were either harmful or beneficial to plants. Drake (34) reported that plants differed greatly in their ability to secure potassium from soil having a low supply of potassium in the exchangeable and soluble forms. He concluded that plants should be used as well as chemical methods in determining the available potassium in a soil.

Neidig and McDole (89) in 1924 found that total analysis of soils was of little practical value in estimating crop yield. They concluded that it was not as important to know the total analysis as it was to know the amount of soluble potassium in the soil. Volk and Troug (134) working with a rapid chemical method found that the soils should contain a minimum of 83 ppm. of readily available potassium for normal plant growth. The minimum value was later adjusted upward (127). Fraps and Fudge (40) showed that there was a significant relation between the quantity of potassium taken up by corn plants and the quantity of acid-soluble or active potassium in the soil.

Numerous workers (19, 33, 39, 100, 104, 108, 115) have succeeded in the calibration of chemical tests for available potassium with crop responses by using weak concentrations of various acids as soil extractants. Workers (4, 8) have also found that exchangeable potassium extractable with neutral ammonium acetate was a reliable measure of the soil potassium available to plants.

Anthony (3) found that seasonal variation was an important factor in the determination of extractable potassium. In three out of four soils examined for available potassium there were variations attributed to seasonal variation.

Soil Fertility Studies in Louisiana

Gouaux (48) was among the first to experiment with fertilizers for sugar cane in Louisiana. He reported in 1929 that results of fertilizer demonstrations with plant cane on alluvial sandy clay loam soils confirmed the recommendations of the Experiment Station in that it was unprofitable to fertilize plant cane on lands where a good crop of soybeans was turned under. However, results of three plant cane fertilizer tests conducted on Crowley silt loam showed very positive returns.

O'Neal and Breaux (90) and O'Neal and Hurst (91) used the Triangle method for testing fertilizers in Louisiana. They reported in 1931 responses of sugar cane to 20 pounds of K_2O per acre on some soil types. O'Neal et al. (92) reported in 1932 that a 12-4-4 fertilizer ratio mixture produced the most profitable yields of sugar cane. O'Neal and Schreiner (93) reported results from fertilizer trials on Lintonia silt loam which showed that the greatest and most consistent increases over unfertilized plots were made with 36-0-24 or 24-0-36 fertilizer mixtures.

Holmes (57) worked with soils in the sugar cane area and reported in 1937 that exchangeable potassium was found to be high, but on several fields there was some response to potassium as more and more nitrogen was added. He found a fairly good correlation between the exchangeable potassium in the soil and the response of sugar cane to fertilizer potassium. Response to potassium was expected at that time where the exchangeable potassium was below 260 ppm. Hendrix (54) reported in 1937 that nitrogen was the only nutrient found to be a limiting factor in the production of sugar cane on Sharkey soils. The

soils studied were so high in available phosphorus, potassium and calcium that the additions of these elements showed relatively little effect in increasing the yield of sugar cane.

Hurst and Holmes (65) in 1938 described the Schreiner triangle method for fertilizer trials and illustrated its application with results from several fertilizer experiments with different varieties of sugar cane on several major soil types. They obtained yield responses from added fertilizer potassium on Lintonia and Iberia soils. They also predicted that as more and more nitrogen is added to the soil a point will be finally reached where nitrogen plus phosphorus or potassium or phosphorus and potassium may give a better sugar cane yield than nitrogen alone. In the western part of the sugar cane area, they found that the deficiencies of phosphorus and potassium were greater than in the eastern part. They extracted exchangeable potassium with a twentieth normal HCl solution at 1:10 soil to solution ratio, and obtained a high negative correlation between exchangeable potassium in the soil and response of sugar cane to fertilizer potassium.

Davidson (31) at the Houma Station reported in 1942 that average results over a period of years indicate that an application of 36 to 40 pounds per acre of nitrogen only was required to produce a normal crop of sugar cane in Louisiana. He (30) also found that with the same amounts of fertilizer there were significantly different yield responses with different varieties of sugar cane.

Walker and Sturgis (139) reported that soil fertility studies in the sugar cane area begun in 1940 showed that wide variations existed in the contents of available nutrient elements as determined by chemical methods. The Mississippi (Pleistocene) terrace soils were

found to be relatively low in available nitrogen, phosphorus and potassium. Heretofore, these soils were considered to be deficient for sugar cane only in nitrogen. They found that the best adapted fertilizer treatment in 1945 was 60 pounds nitrogen, 25 pounds P_2O_5 and 40 pounds of K_2O per acre.

DeMent and Sturgis (32) reported in 1952 results obtained with sugar cane on Lintonia silt loam. The additions of 40 pounds of P_2O_5 and 60 pounds of K_2O with 100 pounds nitrogen per acre increased yield approximately 7 tons per acre over the 100 pounds of nitrogen alone or 16 tons per acre over the check.

Sturgis and Byrnside (125) summarized ten years' work from 1942 to 1951 with complete fertilizers on sugar cane. They reported that the observations of Gouaux through many years of varietal test field work and analytical soil studies by Worsham and Sturgis (140) had by 1941 established the fact that the productive capacity and the available nutrient content of the soils in the sugar cane area were variable and in many cases low. Soil nitrogen was generally low. Forty per cent of the soils tested was so low in easily soluble phosphorus that it was apparent that sugar cane on these soils could be expected to respond to added phosphates. Over 50 per cent of the soils tested was low in exchangeable potassium and response to fertilizer potassium could be expected on the soils testing low in potassium. It was also recognized that other factors such as high soil acidity associated with low availability of calcium and especially magnesium, the development of a plow pan in the soil, and soil acidity in relation to the choice of nitrogen fertilizers might affect the response of sugar cane to complete fertilizers.

Peterson (99) worked with soils in the rice area of Louisiana. He reported that correlations between response of rice to fertilizer potassium and exchangeable soil potassium before treatment were consistently negative, but not statistically significant. Of the soils studied, no soil having less than 2600 ppm. total potassium in the surface soil failed to give a significant yield increase from added fertilizer potassium. Rice on soils testing less than 80 ppm. of exchangeable potassium showed some response to added fertilizer potassium.

Soil Fertility Studies in Florida

Sugar cane yield responses from additions of fertilizer potassium have been obtained by several workers in Florida. Stevens (122) reported in 1933 that fertilizer potassium was found to be the most important fertilizer for early use on muck soils in the production of sugar cane. Striking tonnage increases were obtained with moderate applications of potassium on the first crop grown on freshly broken land of good quality. Bregger and Bedsole (21) in 1953 reported increases in sugar cane and sugar yields from applications of fertilizer potassium. According to Legrand (77) sugar cane grown on organic soils in Florida did not respond to additions of nitrogen, but on most fields yields were higher after the application of potassium.

Soil Fertility Studies in Hawaii

Halliday (50) has reviewed the world-wide literature on the manuring of sugar cane. Several workers in foreign countries have reported responses of sugar cane to fertilizer potassium. Humbert (63) did

extensive work with potassium fertilization in the Hawaiian sugar industry. He reported that responses to fertilizer potassium ranging from one to three tons of sugar per acre were correlated with exchangeable soil potassium. Significant responses in sugar yields were obtained where the level of exchangeable potassium was 190 pounds or less per acre foot. According to Humbert, the conversion of reducing sugars to sucrose prior to harvest time is believed to be related to the balance between nitrogen and potassium. Adequate potassium must be available to utilize the "unused" nitrogen to bring about a stage of maturity where the bulk of the reducing sugars are converted to sucrose.

Humbert (61) reported results from 31 replicated experiments which showed that the critical level of exchangeable soil potassium was 75 ppm. Significant increases from fertilizer potassium were obtained in some cases between 75 and 110 ppm. Above 110 ppm. fertilizer potassium was applied strictly for insurance purposes. He pointed out that the only exceptions were found in the low volume weight soils where for a given level of potassium expressed in ppm. the amount of potassium per acre foot was considerably lower than in the high volume weight soils for which the critical level was initially established. In the amounts-of-potassium tests, 40 per cent of the experiments showed significant gains from fertilizer potassium.

Ayres and Hagihara (9) obtained results from 57 experiments in Hawaii similar to those obtained by Humbert. They found an increase of 175 per cent in yield at the extremely low soil potassium level of 30 ppm. and about 35 per cent at 40 ppm. Above 40 ppm. the response curve dropped less until about 100 ppm. potassium it became horizontal, suggesting little likelihood of response to the addition of fertilizer

potassium at soil potassium levels in excess of 100 ppm. The potassium was extracted with ammonium acetate adjusted at pH 7.0. Very few experiments in which supplies of potassium were below 75 ppm. failed to respond. According to Bayer (13) the deficiency-sufficiency range for available potassium in sugar cane soils was 100-162 ppm. Magistad (84) reported increased yields of pineapple from potassium applied to soils containing 80 ppm. or less of exchangeable potassium.

Silva, Darroch and Humbert (117) summarized the results of 22 potassium experiments on the Island of Hawaii and 90 potassium experiments on the Island of Kauai conducted from 1950 to 1957. Polynomial Yield equations which included terms for soil potassium (K), the square root of applied potassium ($k^{\frac{1}{2}}$) and their product ($Kk^{\frac{1}{2}}$) were developed to describe the yield response (Y) for each of these islands. The normal form of the equation from Hawaii which gave the best fit was:

$$Y = 0.001940 K + 0.448215 k^{\frac{1}{2}} - 0.000451 Kk^{\frac{1}{2}} - 1.759797 .$$

This equation had a coefficient of 0.797 and explained 63.5 per cent of the variation in yield.

Burr (24) in Hawaii reported potassium responses measured in tests on individual plantations. The response to added fertilizer potassium was remarkably uniform in spite of the wide range of absolute values resulting from variable levels of soil potassium on the different plantations.

Although responses of sugar cane to fertilizer potassium were measured where the available soil potassium was low, it is conceivable that the misuse of fertilizer may result in little or no response and possibly harmful effects. Clements (29) found that when all the potassium was applied under the seed piece at planting time he obtained

no response, while subsequent studies showed the soils to be seriously deficient in potassium. Clements also pointed out that excessive applications of fertilizer potassium increased the potassium content of the millable cane so high that the KCl crystallized sooner than the sucrose in the sugar boilers thus blocking the drainage system of the centrifuges.

Soil Fertility Studies in Other Countries

Bonnet (15) reported in Puerto Rico significant responses of sugar cane to 90 pounds of K_2O per acre per crop per year. Innes and Chinley (67) in Jamaica found that the average response of sugar cane to potassium varied according to soil type. The mean percentage response to 130-163 pounds K_2O applied per acre varied from 3.5 per cent on irrigated clay alluvia to 77.6 per cent on dry inland basin alluvia soils. Where there was a yield response to the addition of fertilizer potassium, juice quality was also improved. Walker (136) in British Guiana agreed that soil type was a major factor in measuring yield responses from fertilizer potassium. He obtained increases in yield of 5 per cent on clay soils and up to 13 per cent on lighter soils.

Aughtry and Lunin (5) in the Dominican Republic reported no appreciable increase in sugar cane yield from applying potassium at a rate of 119 pounds of K_2O per acre. Aguirre (1) in Brazil reported an average response of 5.3 tons of sugar cane to 87 pounds of K_2O added per acre. In Trinidad, Carey and Robinson (28) and Jack (68) reported responses to fertilizer potassium. Jack concluded that scorching of sugar cane leaves associated with applying sulphate of ammonia was due to potassium deficiency, probably induced by the nitrogen application.

Saint (110) in Barbados found that, on coral limestone soils, if the top soil contained less than 116-133 ppm. of exchangeable potassium the yield of sugar cane was limited by a deficiency of potassium.

Fertilizer trials in South Africa (114) showed that a high correlation existed between soil potassium and yield response of sugar cane to fertilizer potassium. Yield responses were obtained where the soil K_2O level was 250 pounds or less per acre. Lintner (78) and du Toit (37) in Natal indicated that potassium deficiency symptoms in sugar cane were becoming more widespread. du Toit (38) reported a 1300 per cent increase in potash usage for sugar cane during a nine year period ending in 1959.

Hodnett (56) used an equation based on Mitscherlich's equation for estimating responses of sugar cane to fertilizer applications in experiments conducted in the British Colonial and Commonwealth Territories. He reported that fertilizer nitrogen had a depressing effect while fertilizer potassium increased the sugar percentage. The effect of fertilizer phosphate was generally small and irregular.

Kerr and von Stieglitz (73) and von Stieglitz (135) in Australia correlated soil potassium with response of sugar cane to fertilizer potassium and obtained the following standards for assessing fertility levels for soil potassium:

Very low, less than 39 ppm. of exchangeable potassium.

Low, 39-47 ppm. of exchangeable potassium or less than 2 per cent of total exchangeable bases.

Medium, 47-70 ppm. of exchangeable potassium and more than 2 per cent of total exchangeable bases.

High, more than 70 ppm. of exchangeable potassium and more than 2 per cent of total exchangeable bases.

Locsin (79, 80) and Smith (119) conducted sugar cane fertilizer experiments in the Victorias. They recommended fertilizer ratios that included 81 to 130 pounds of K_2O per acre.

According to Halliday (50) the present world-wide recommendations of fertilizer potassium for sugar cane at various levels of soil potassium are generally as follows:

Exchangeable Soil K ppm.	K_2O Recommended lbs./A.
More than 130	0
130 to 100	82
100 to 70	130
Less than 70	163 or more

Potassium Deficiency in Sugar Cane

Hartt (53) reported in 1929 that potassium deficient sugar cane plants had greater percentages of total sugars, reducing sugars and sucrose than the plants supplied with potassium. Hartt (52) also reported that the percentage of iron in most tissues, especially in the nodes of sugar cane, was higher under conditions of potassium shortage. Humbert (64) was not in complete agreement with Hartt on the sugar content of sugar cane in that he found that potassium deficiency resulted in higher reducing sugars, lower sucrose, lower purities and higher tons millable cane per ton sugar.

Martin (85) found that the first visible potassium deficiency symptom in sugar cane was the retardation in growth. He observed that the stalks tapered rapidly toward the growing point and that the tops assumed a fan-like appearance. He reported that older leaves died back

from the tips and margins, resulting in a definite firing of the leaf edges, and changed from a dark green to a pale yellowish color with numerous minute chlorotic spots. According to Venema (130) young leaves of potassium deficient sugar cane plants were dark green becoming pale yellow with definite reddish discolorations on the upper surfaces of the midribs.

According to Hartt (52) the variation in potassium content of sugar cane leaves with age have led many investigators to conclude that potassium migrated from the leaves back to the stalk before the leaves became physiologically inactive.

Effects of Fertilizer Potassium on Juice Quality of Sugar Cane

Although considerable work has been done on the effects of fertilizers on the quality of sugar cane juice, the effect of fertilizer potassium on percentage sucrose is still a controversial issue.

Geerligs (42) reported in 1911 that the potassium content of sugar cane juice was used as a criteria of a probable high sugar content and a high purity at maturity. He found that plants having the lowest potassium content ultimately contained the best sugar content and quotient of purity of the juice. This was not in agreement with the findings of most workers.

Verret (132) found that fertilizer potassium had no effect on the juice quality of sugar cane. Alexander (2) reported the results of a six-year study in which he showed that the sucrose content of sugar cane may have been improved by potassium fertilization. Naquin (88) reported that sugar cane receiving fertilizer potassium and nitrogen gave better quality juice than nitrogen alone. According to Ulrich (128)

the sugar content of sugar beet roots is markedly reduced at high levels of fertilizer nitrogen. Borden (16) concluded that the more fertilizer potassium and nitrogen applied to sugar cane under poor light conditions, the greater the moisture content of the cane, and consequently the lower the juice quality.

Samuels (111) and Samuels and Landrau (112, 113) in Puerto Rico have done the most extensive work on the influence of fertilizers on sucrose content of sugar cane. They found that fertilizer potassium applications increased the sucrose content of sugar cane only when significant increases in cane tonnage were obtained.

Potassium Uptake by Sugar Cane

Nutrient uptake by sugar cane has been under scrutiny in Louisiana since the beginning of the twentieth century. Browne (23) in 1907 published an Experiment Station bulletin on the chemistry of sugar cane in Louisiana. McKaig (87) has probably done the most extensive work on nutrient uptake of sugar cane. He concentrated mainly on chemical composition of sugar cane juice as affected by fertilizer. He concluded that fertilization caused a greater change in the chemical composition of the juice in the western than in the eastern section of the Louisiana sugar cane area. Holmes (58) found a good correlation between "free" potassium in sugar cane juice and exchangeable potassium in the soil.

Several workers have correlated the potassium content in various sugar cane plant parts with available soil potassium. Bayer (12) found a highly significant correlation of 0.909 between available soil potassium and percentage potassium in the leaf sheath. He concluded

that potassium fertilization generally had a rather pronounced effect upon the potassium concentration in the stalk and leaf-sheath tissues of sugar cane. Innes (66) showed that the basal stalk-potassium was more sensitive to potassium applications than the leaf-potassium.

Ayres (6, 7) reported that the potassium concentration in mature stalks of sugar cane was higher than that of any other element. He found that the meristematic tissue lost potassium as it matured by upward migration of the nutrient element.

Stage of growth apparently has an outstanding effect on the uptake and accumulation of potassium in sugar cane plants. Borden (18) and Halliday (50) found that potassium, like nitrogen, was taken up rapidly during the earlier periods of growth. They reported evidence of luxury consumption of potassium when ample supplies were available and of actual loss in the later stages of growth. Burr and Tanimoto (25) found that a well-fed sugar cane plant contained three times as much potassium as a potassium starved plant. Singh (118) reported that the sugar cane stalk acted as a storage sink during rapid accumulation of potassium in early stages of growth.

Phillips (101) reported results from greenhouse and field sugar cane experiments which indicated that the total potassium uptake was a more precise measurement of available soil potassium than the percentage potassium in the whole plant.

Several workers have attempted to establish the amount of potassium required to produce a ton of sugar cane. According to Lawton and Cook (75) an acre yield of 30 tons of green stalks, leaves and tops removed only 43 pounds of K_2O . This amount was much lower than that reported by other workers. Verret (131) in Hawaii found that a

ton of millable cane removed from two to three pounds of K_2O from the soil. Vallance (129) in Queensland showed that a ton of millable cane removed 3.1 pounds of K_2O .

Borden (17) reported that each ton of millable cane that was produced at nine months of age had a potassium requirement of 7.5 pounds of K_2O per ton. He concluded that although the total amount of potassium taken out of the soil was large, a large percentage of this potassium was left in the field in the trash, tops and roots. However, in Louisiana, where the sugar cane trash is burned at harvest, a portion of the potassium contained in the ashes may be lost. Sturgis (124) reported in 1959 that sugar cane grown on 268,000 acres in Louisiana removed almost 12,000 tons of K_2O in millable cane and an additional loss of 9,000 tons of K_2O from burning of trash. The loss from burning trash was apparently due to the washing of the water-soluble potassium in the ashes into drainage water under heavy rainfall conditions. The potassium removal by sugar cane was based on the estimation that 6.4 pounds of K_2O are absorbed by the crop for the production of one ton of millable cane.

MATERIAL AND METHODS

Soil types of the sugar cane area of Louisiana have been generally described by Lytle and Sturgis (83). Detailed descriptions of the soil types studied are given in Soil Survey Reports of the parishes, published by the United States Department of Agriculture, S. C. S. and Louisiana Agricultural Experiment Station. A large percentage of the sugar cane is grown on the relatively immature and fertile younger alluvial soils of the Mississippi and Red River flood plains. The Commerce, Mhoon and Sharkey series are alluvial soils derived from Mississippi alluvium. Yahola series is a reddish calcareous alluvial soil that occurs in the flood plains of the Red River and its distributaries.

Geologically older soils of the Cypremort, Baldwin, Jeanerette, Iberia and Patoutville series were developed on low-lying stream terraces which were probably formed by the Mississippi River and its distributaries in the late Pleistocene or the early Recent. The soils of the Richland and Olivier series are the oldest soils in the sugar cane area and occur on the Pleistocene Mississippi terraces.

Soil and Plant Material

Samples and data from 49 fertilizer experiments with sugar cane conducted at 28 experimental locations in the sugar cane area by the Agronomy Department of the Louisiana Agricultural Experiment Station during a ten-year period from 1954 through 1963 were used in this study.

The fertilizer treatments in each experiment were replicated three times in a randomized block design. The plot size was approximately one-tenth acre. Fertilizers were mixed from ammonium nitrate, 20 per cent superphosphate and 60 per cent muriate of potash. Fertilizers were applied by hand in the off-bar furrow in spring. Fertilizer treatments applied to plant and stubble cane were as follows:

Plant Cane		Stubble Cane	
1954 to 1959	1960 to 1963	1954 to 1959	1960 to 1963
N-P ₂ O ₅ -K ₂ O	N-P ₂ O ₅ -K ₂ O	N-P ₂ O ₅ -K ₂ O	N-P ₂ O ₅ -K ₂ O
Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
0-0-0	0-0-0	0-0-0	0-0-0
40-0-0	40-0-0	80-0-0	80-0-0
40-0-60	40-0-80	80-0-60	80-0-80
40-40-0 ¹	40-40-0	80-40-0 ¹	80-40-0
40-40-60	40-40-80	80-40-60	80-40-80
60-0-0	80-0-0	100-0-0	120-0-0
60-0-60	80-0-80	100-0-60	120-0-80
60-40-0 ¹	80-40-0	100-40-0 ¹	120-40-0
60-40-60	80-40-80	100-40-60	120-40-80
80-0-0	120-0-0	120-0-0	160-0-0
80-0-60	120-0-80	120-0-60	160-0-80
80-40-0 ¹	120-40-0	120-40-0 ¹	160-40-0
80-40-60	120-40-80	120-40-60	160-40-80

¹Fertilizer treatments used only in 1958 and 1959 experiments.

Three rates of nitrogen were applied to both plant and stubble cane, but lower rates were applied to plant than to stubble cane. Two rates of phosphorus and two rates of potassium were applied to both plant and stubble cane. A 3 x 2 x 2 factorial type experiment with nitrogen,

phosphorus and potassium was used after 1957. Due to increasing responses to fertilizer nitrogen and potassium, higher rates of each were used after 1959. When possible the fertilizer experiments were continued at the same locations during the plant, first and second stubble cane years.

Cultivation and the control of weeds, diseases and insects were followed during the growing season according to plantation practices at each location. Precipitation was measured at each location with rain gauges. At harvest, the sugar cane on each plot was topped, cut and piled in a heap row with a cane harvester. After burning the dry leaves, the millable cane was loaded on tractor carts and weighed. The percentage trash in the millable cane was determined and yield was recorded in tons per acre of clean cane.

A ten stalk sample was collected from each plot and sucrose, brix and purity analyses were made in the mill laboratory for each experimental location. Percentage sucrose and cane yield were used to determine the amount of sugar produced on each plot. Response of sugar cane to fertilizer potassium was measured by comparing the N-K treatment with the N treatment and the N-P-K treatment with the N-P treatment at each of the three N levels. Since an analysis of variance on the yield data obtained from each factorial experiment revealed that the $N \times K$, $P \times K$ and $N \times P \times K$ interactions were not generally statistically significant, the response to applied potassium was calculated as an average of the three nitrogen levels with and without phosphorus. The average response was calculated in accordance with techniques described by LeClerc et al (76).

A surface soil sample was taken in spring prior to fertilization at each of the 28 experimental locations. The samples were air-dried, pulverized, passed through a 2 mm. sieve and stored in ice cream cartons to await analysis.

Whole-stool sugar cane samples were taken at harvest from six replicated fertilizer plots at two locations in 1961 and 1962 to study the effects of fertilizer potassium on potassium uptake and on percentage sucrose in sugar cane. One location on alluvial soil and another location on terrace soil was chosen for this study each year. Approximately 200-pound samples of cane stalks were cut and weighed from each plot. The stalks were cleaned and topped at the last hard joint. The millable cane was weighed and the weight of tops and trash was obtained by difference between the total stalk weight and the millable cane weight. The millable cane was crushed with a hand mill. The baggasse was weighed and the juice weight was obtained by the difference between millable cane and the baggasse weights. The juice was sampled for sucrose, brix and purity analyses and for potassium analysis. The tops and trash and the baggasse were ground separately in a forage harvester and sampled for potassium analysis and moisture determination. All analyses are reported on a dry basis, 60° C. The uptake of potassium per acre contained in the tops and trash, juice and baggasse was calculated by using the percentage of potassium and weight of each plant part and total yield from each plot. The sum of the potassium contents of tops and trash, juice and baggasse was the total uptake by the above-ground growth. The sum of the potassium contents of the juice and baggasse was the uptake by the millable cane.

Soil Analysis Procedures

Available soil cations

Surface soil samples from the 28 experimental locations were analyzed for available or extractable soil K, Ca, Mg and Na. The available cations were extracted with 0.1 N hydrochloric acid and with 1.0 N ammonium acetate buffered at pH 7.0 at 1:10 and 1:20 soil to solution ratios. This was done by weighing, in duplicate, 10 grams and 5 grams of air-dried soil for the 1:10 and 1:20 ratios, respectively, into 250 ml. flasks and adding 100 ml. of the extractant to each flask. The samples were then shaken for 20 minutes on a mechanical shaker and filtered immediately through Whatman's No. 12 filter paper into sample bottles. The K, Ca, Mg and Na determinations of the filtrate were made with a Beckman Model DU spectrophotometer, with flame attachment and photomultiplier assembly. The instrument was operated according to the manufacturer's manual. Standard solutions containing a range of known concentrations of each cation were prepared and used in the calibration of the photometer. A set of standard solutions was prepared for each extracting solution which contained the same concentration of the extractant as the extracting solution. Instrument readings were obtained for each standard solution and unknown sample. A calibration curve was constructed and the concentration of each cation was calculated from the curve. A moisture determination was made on each soil sample and the data are reported on oven-dried basis, 105° C.

Exchangeable soil cations

The soil samples were analyzed for exchangeable soil K, Ca, Mg and Na by the method as described by Peech et al (98). A 25 gram sample

from each soil was weighed in duplicate into a 250 ml. flask, 100 ml. of 1.0 N ammonium acetate, buffered at pH 7.0, were added, shook for 30 minutes and allowed to stand over night. Then the samples were filtered using a Buchner funnel fitted with Whatman's No. 12 filter paper, applying gentle suction. The samples were leached with additional 250 ml. of the extractant in 25-50 ml. portions. After filtration the exchangeable cations in the filtrates were determined in the same manner as described for the available cations.

Exchangeable soil hydrogen

Exchangeable hydrogen in each soil sample was determined by the barium acetate method as described by Jackson (69). A 15 gram sample was weighed in duplicate into a 250 ml. flask, 100 ml. of 0.5 N barium acetate adjusted to pH 7.5 were added and stirred intermittently for two hours. Then the samples were filtered using a Buchner funnel fitted with Whatman's No. 12 filter paper, applying gentle suction. The samples were leached with additional 250 ml. of the extractant in 25-50 ml. portions. After filtration, 10 drops of phenolphthalein indicator solution were added to the filtrate and back titrated with standardized 0.1 N sodium hydroxide. A blank titration was made on the extractant and subtracted from the titration value of the unknown samples. The exchangeable hydrogen expressed in the milli-equivalents per 100 grams of oven-dried soil was calculated in the following manner:

$$\text{me. H/100 gm.} = \frac{\text{ml. of NaOH} \times \text{normality of NaOH} \times 100}{\text{sample weight}}$$

Cation exchange capacity and percentage base saturation

Cation exchange capacity of each soil was determined by the summation of the exchangeable bases and exchangeable hydrogen. The

percentage base saturation was calculated by dividing the base exchange capacity by the cation exchange capacity times 100.

Total soil potassium

Total potassium in each soil sample was determined by hydrofluoric acid digestion method as described by Jackson (69). Duplicate 0.5 gram samples of soil which had been ground to pass through a 100 mesh sieve were weighed into platinum crucibles and treated with 10 drops of concentrated sulfuric acid and 15 ml. of 48 per cent hydrofluoric acid. The crucibles were heated almost to dryness, then treated with an additional 5 ml. of hydrofluoric acid and heated to dryness. The residues were dissolved in 250 ml. beakers containing a weak solution of nitric acid then heated to dryness and treated again with 4:1 nitric-perchloric acids to completely oxidize the organic matter. The residues were taken up with 10 ml. of 5 N hydrochloric acid and filtered into 100 ml. volumetric flasks and made up to volume. The total potassium in the filtrates was determined in the same manner as described for the available soil potassium.

Soil reaction

The pH of the soil samples was determined with a Beckman Zeromatic pH meter equipped with a glass electrode and a saturated calomel reference electrode. A 25 gram sample was weighed in duplicate into a 100 ml. beaker and 25 ml. of distilled water were added. The samples were stirred several times and allowed to stand over night. Then the pH was measured after proper calibration of the instrument with buffer solutions.

Soil organic matter

Organic matter in each soil sample was determined by the dry combustion method. The apparatus used and procedures followed were as described by Piper (103).

Total soil nitrogen

Total nitrogen in each soil sample was determined by the Kjeldahl method as described by Jackson (69).

Soil particle size analysis

Percentages of sand, silt and clay in each soil sample were determined by the hydrometer method as modified by Patrick (95). Textural class of the soils was determined as described in the Soil Survey Manual, United States Department of Agriculture Handbook, 1937, page 18.

Plant Analysis Procedures

The total potassium content of the tops, baggasse and juice samples was determined by the wet acid digest method developed by Toth, Prince, Wallace and Mikkelsen (126). A 0.5 gram sample was weighed in duplicate from each air-dried plant sample and placed in a 150 ml. beaker and covered with a ribbed watch glass. Twelve ml. of concentrated nitric acid were added to the samples and allowed to stand over night. Then, 4 ml. of 70 per cent perchloric acid were added and the samples were placed on a hot plate and allowed to digest until all solids were converted to liquid form and the organic matter had been removed as evidenced by the loss of the brown color. The samples were allowed to evaporate almost to dryness, then removed from the hot plate and cooled, leaving only the mineral elements, including silica.

In order to remove the silica, 10 ml. of 5 N hydrochloric acid were added to each sample, heated to almost boiling and transferred quantitatively by filtering through Whatman's No. 42 filter paper into 100 ml. volumetric flasks. Potassium in the filtrates was determined with a flame photometer in the manner described for available soil potassium.

Methods for Statistical Analysis

The statistical analysis methods used are described by Snedecor (120) and LeClerc (76). Linear and curvilinear regression equations and simple correlation coefficients were calculated between some of the chemical and physical properties of the 28 soils studied.

An analysis of variance was calculated on the yield data obtained from each of the 49 fertilizer experiments to determine the significance of the response due to the additions of fertilizer potassium. Regression equations were obtained to show the relationship between available or extractable soil potassium and response of sugar cane to fertilizer potassium.

An analysis of variance was calculated on the potassium uptake data obtained at each of the four locations studied to determine the significance of the effect of fertilizers on potassium uptake by sugar cane.

Simple correlation coefficients were obtained between rainfall during different periods of the year and yield of sugar cane in the fertilizer experiments.

EXPERIMENTAL RESULTS AND DISCUSSION

Experimental locations and the soil type at each location where the fertilizer experiments with sugar cane were conducted are shown in Table 1. Twenty-two experiments were conducted at 12 locations (Nos. 1-12) on Alluvial soils of the Mississippi and Red Rivers flood plains. Twenty-seven experiments were conducted at 16 locations (Nos. 13-28) on Older Alluvial or Terrace soils bordering Bayou Teche in the western section of the sugar cane area.

Chemical and Physical Properties of the Soils

Data obtained on the chemical and physical properties of the soils studied are presented in Tables 2 through 8. Simple correlation coefficients among the properties of the soils are presented in Table 9.

Potassium content of the soils

Data on soil potassium are shown in Table 2. Available soil potassium extracted with either 0.1 N hydrochloric acid or with 1.0 N ammonium acetate was slightly higher at the 1:20 than at the 1:10 soil to solution ratio. The ammonium acetate solution extracted considerably more potassium than the hydrochloric acid solution at either ratio, particularly from soils high in clay content. Available potassium extracted with 0.1 N hydrochloric acid at the 1:20 varied from 57 ppm. in Moon silt loam to 311 ppm. in Sharkey clay, with an average of 121 ppm. for the Alluvial soils. In the Older Alluvial or Terrace soils,

Table 1. Soil types and location of experiments with fertilizers for sugar cane on Alluvial soils (Nos. 1-12) and Older Alluvial or Terrace soils (Nos. 13-28).

Exp. Loc. No.	Soil Type	Depth Sampled, Inches	Plantation	Year of Experiment		
				Plant Cane	1st Stubble	2nd Stubble
1	Yahola sil	0-8	Edgefield	1959		
2	Commerce l	0-8	Smithfield	1954		1956
3	Commerce sil	0-8	Smithfield	1959	1960	
4	Commerce sil	0-8	Alma	1962	1963	
5	Mhoon l	0-7	Little Texas	1954	1955	1956
6	Mhoon sil	0-7	Little Texas		1958	1959
7	Mhoon sil	0-8	Warren Harang		1963	
8	Mhoon sil	0-8	Smithfield		1958	
9	Mhoon sil	0-8	Little Texas	1960	1961	1962
10	Mhoon sil	0-8	Pecan Tree		1960	1961
11	Mhoon sil	0-8	Caldwell		1963	
12	Sharkey c	0-8	Pecan Tree	1962	1963	
13	Cypremort sil	0-8	Alice "B"		1961	
14	Baldwin sil	0-7	Alice "B"	1956	1957	1958
15	Baldwin sil	0-7	Alice "B"	1962	1963	
16	Baldwin sil	0-5	O'Neil	1958	1959	1960
17	Jeanerette sil	0-8	Alice "B"	1959	1960	
18	Jeanerette sil	0-8	St. John	1963		
19	Jeanerette sil	0-8	Patout		1961	
20	Jeanerette sil	0-8	Patout	1962	1963	
21	Iberia sil	0-7	Katy	1955	1956	
22	Iberia sil	0-7	Cherry Grove	1956		
23	Patoutville sil	0-6	Vaufrey	1955		
24	Patoutville sil	0-6	Vaufrey	1956		
25	Richland sil	0-7	Young's Ind.	1954	1955	
26	Richland sil	0-7	Young's Ind.	1956		
27	Richland sil	0-7	Billeaud		1957	
28	Olivier sil	0-8	Young's Ind.	1959	1960	1961

Table 2. Potassium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction.

Exp. Loc. No.	Available Soil K				Exchangeable K	K Saturation	Total K	
	0.1 N HCl		1.0 N NH ₄ OAc					
	1:10	1:20	1:10	1:20				
	ppm.	ppm.	ppm.	ppm.	ppm.	me./ 100 g.	%	%
1	75	93	79	88	94	0.24	1.3	1.76
2	89	96	88	95	113	0.29	2.5	2.03
3	76	86	82	85	110	0.29	1.8	2.06
4	79	92	76	101	126	0.32	2.8	1.91
5	108	117	112	116	127	0.32	1.8	1.96
6	65	78	67	74	85	0.21	1.3	2.10
7	103	111	121	124	141	0.36	1.7	1.79
8	51	57	49	54	65	0.16	1.7	1.90
9	73	78	74	77	72	0.18	1.1	2.16
10	100	110	121	122	151	0.39	1.4	2.19
11	212	227	267	265	299	0.76	2.2	1.96
12	249	311	398	406	585	1.49	2.9	2.19
Av. 1-12	107	121	128	134	164		1.9	2.00
13	33	47	44	48	46	0.12	1.1	1.60
14	52	61	54	62	65	0.16	1.0	1.77
15	62	66	58	61	76	0.19	1.0	1.65
16	131	155	174	190	201	0.51	1.8	1.95
17	82	104	88	95	108	0.28	1.0	1.90
18	73	80	74	80	88	0.23	1.0	1.51
19	46	59	47	55	56	0.14	0.5	1.26
20	76	80	74	76	85	0.21	1.2	1.20
21	58	67	56	63	68	0.17	0.8	1.62
22	75	85	64	75	73	0.19	0.5	1.20
23	69	75	81	90	84	0.21	2.0	1.22
24	44	47	47	54	50	0.13	1.5	1.26
25	74	82	93	95	98	0.25	1.8	1.44
26	85	94	106	108	110	0.28	2.2	1.45
27	62	69	72	79	84	0.21	1.9	1.38
28	46	58	56	62	67	0.17	1.4	1.43
Av. 13-28	67	77	74	81	85		1.3	1.49

Table 3. Calcium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction.

Exp. Loc. No.	Available		Soil Ca		Exchangeable Ca	Ca	
	0.1 N	HCl	1.0 N	NH ₄ OAc		Saturation	
	1:10	1:20	1:10	1:20		me./ 100 g.	%
	ppm.	ppm.	ppm.	ppm.	ppm.		
1	3971	4615	2568	3157	3329	16.65	85.5
2	1177	1297	1218	1311	1383	6.92	60.0
3	1934	2103	1764	2089	2042	10.21	63.4
4	1176	1174	1191	1290	1308	6.54	56.4
5	2103	2083	1879	2450	2205	11.03	61.6
6	1907	1993	1797	1995	2021	10.11	60.7
7	2147	2229	2250	2601	2518	12.59	58.7
8	1190	1378	1129	1289	1261	6.31	65.9
9	1785	1979	1906	2087	2193	10.97	65.2
10	3248	3444	3279	3556	3641	18.21	65.2
11	3707	3959	4170	4254	4591	22.96	65.3
12	5747	5805	5741	6173	6740	33.70	66.2
Av. 1-12		2672		2688	2769		64.5
13	685	771	912	1045	1015	5.08	45.4
14	1709	1732	1702	1832	1972	9.86	58.2
15	2871	3228	2675	2781	3073	15.37	76.0
16	1039	1469	1961	2165	2276	11.38	39.4
17	3801	3930	3254	3471	3764	18.82	68.0
18	2866	2949	2413	2784	2722	13.61	61.7
19	5562	6625	4023	4932	5222	26.11	81.6
20	2046	2369	2103	2160	2352	11.76	65.9
21	2335	2543	2238	2514	2711	13.56	63.0
22	9129	10420	5247	6334	6044	30.22	83.2
23	365	406	588	670	730	3.65	34.6
24	294	477	487	589	547	2.74	30.1
25	305	325	609	670	731	3.66	26.0
26	284	284	589	670	691	3.46	27.4
27	416	496	622	675	751	3.75	32.6
28	437	497	663	728	794	3.97	32.4
Av. 13-28		2408		2126	2212		51.6

Table 4. Magnesium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction.

Exp. Loc. No.	Available		Soil Mg		Exchangeable Mg	Mg Saturation	
	0.1 N	HCl	1.0 N	NH ₄ OAc			
	1:10	1:20	1:10	1:20			
	ppm.	ppm.	ppm.	ppm.	ppm.	me./ 100 g.	%
1	896	947	275	296	308	2.52	12.9
2	316	430	307	316	324	2.65	23.0
3	515	686	492	521	562	4.60	28.6
4	265	331	266	270	274	2.24	19.3
5	511	584	480	511	490	4.02	22.4
6	476	549	427	498	492	4.03	24.2
7	733	733	590	650	578	3.74	17.4
8	346	507	211	316	308	2.52	26.3
9	571	718	477	520	526	4.31	25.7
10	895	999	790	854	872	7.15	25.6
11	948	1205	893	990	842	6.90	19.6
12	1393	1565	1314	1329	1546	12.67	24.9
Av. 1-12		771		589	594		22.5
13	274	281	255	262	256	2.10	18.8
14	446	537	409	430	456	3.73	22.4
15	478	598	455	470	492	4.03	19.9
16	750	738	693	745	754	6.18	21.4
17	814	967	783	824	848	6.95	25.1
18	837	1089	732	792	696	5.71	25.9
19	762	820	613	639	670	5.49	17.2
20	478	535	416	535	492	4.03	22.6
21	518	534	495	524	530	4.34	20.2
22	1019	1031	684	712	708	5.81	16.0
23	254	278	254	254	269	2.20	20.9
24	317	353	243	296	291	2.39	26.2
25	139	183	152	183	164	1.34	9.5
26	188	183	188	207	191	1.57	12.5
27	239	234	179	189	203	1.67	14.5
28	177	169	119	169	151	1.23	10.1
Av. 13-28		533		452	448		19.0

Table 5. Sodium content of Alluvial soils and Older Alluvial or Terrace soils by various methods of extraction.

Exp. Loc. No.	Available		Soil Na		Exchangeable Na	Na Saturation	
	0.1 N	HCl	1.0 N	NH ₄ OAc			
	1:10	1:20	1:10	1:20			
	ppm.	ppm.	ppm.	ppm.	ppm.	me./ 100 g.	%
1	49	82	20	46	16	0.07	0.4
2	49	86	33	59	25	0.11	1.0
3	42	70	19	46	19	0.08	0.5
4	31	71	27	52	39	0.17	1.5
5	92	112	69	108	57	0.25	1.4
6	54	114	46	69	42	0.18	1.1
7	80	99	60	101	56	0.24	1.1
8	35	63	25	50	25	0.11	1.2
9	51	78	36	59	31	0.13	0.8
10	61	105	33	60	31	0.14	0.5
11	122	126	88	82	59	0.26	0.7
12	62	103	60	110	49	0.22	0.4
Av. 1-12		92		70	37		0.9
13	52	90	38	64	33	0.14	1.3
14	57	69	61	95	57	0.24	1.4
15	67	92	39	91	52	0.22	1.1
16	63	71	56	89	51	0.22	0.8
17	132	175	123	147	125	0.55	2.0
18	100	134	95	113	121	0.53	2.4
19	36	41	23	54	20	0.08	0.3
20	42	67	28	63	28	0.12	0.7
21	84	96	56	91	55	0.24	1.1
22	45	82	26	70	25	0.10	0.3
23	71	110	63	112	49	0.21	2.0
24	65	94	51	86	54	0.23	2.6
25	55	99	43	97	24	0.10	0.7
26	57	96	47	100	28	0.12	1.0
27	54	82	34	61	31	0.13	1.1
28	35	59	17	38	14	0.06	0.5
Av. 13-28		91		86	48		1.2

Table 6. Exchange properties in milli-equivalents per 100 grams of dry soil and pH values of Alluvial soils and Older Alluvial or Terrace soils.

Exp. Loc. No.	Base Exchange Capacity	Exchangeable Hydrogen	Cation Exchange Capacity	Percentage Base Saturation	Soil pH
1	19.48	--	19.48	100.0 ¹	7.3
2	9.98	1.55	11.53	86.6	6.0
3	15.18	0.92	16.10	94.3	6.9
4	9.28	2.32	11.60	80.0	5.6
5	15.62	2.30	17.92	87.2	6.2
6	14.54	2.10	16.64	87.4	5.9
7	16.93	4.52	21.45	78.9	5.7
8	9.11	0.48	9.58	95.0	6.9
9	15.60	1.21	16.81	92.8	6.8
10	25.88	2.04	27.92	92.7	6.4
11	30.88	4.30	35.18	87.8	6.2
12	48.08	2.81	50.89	94.5	6.6
Av. 1-12	19.21		21.26	89.8	
13	7.44	3.75	11.19	66.5	4.9
14	14.00	2.95	16.95	82.6	5.7
15	19.82	0.41	20.23	98.0	7.1
16	18.29	10.59	28.89	63.3	4.8
17	26.60	1.06	27.66	96.2	6.8
18	20.08	1.98	22.06	91.0	7.0
19	31.83	0.18	32.00	99.5	7.2
20	16.13	1.73	17.86	90.3	6.7
21	18.31	3.21	21.53	85.1	5.8
22	36.32	--	36.32	100.0 ¹	7.3
23	6.27	4.27	10.54	59.5	5.2
24	5.49	3.60	9.09	60.4	5.2
25	5.35	8.73	14.08	38.0	5.1
26	5.43	7.18	12.61	43.1	5.0
27	5.77	5.75	11.51	50.1	5.5
28	5.45	6.81	12.25	44.5	5.3
Av. 13-28	15.16		19.05	73.0	

Table 7. Clay, organic matter, total nitrogen and available phosphorus contents of Alluvial soils and Older Alluvial soils or Terrace soils.

Exp. Loc. No.	Soil Type	Clay	Organic Matter	Total N	N in O.M.	Avail. ¹ P
		%	%	%	%	ppm.
1	Yahola sil	11.4	1.02	0.041	4.02	241
2	Commerce l	10.1	1.10	0.067	6.10	330
3	Commerce sil	14.8	1.42	0.067	4.72	299
4	Commerce sil	9.6	1.18	0.064	5.42	237
5	Mhoon l	17.9	1.24	0.076	6.13	205
6	Mhoon sil	16.1	1.18	0.066	5.59	216
7	Mhoon sil	24.5	1.40	0.086	6.14	181
8	Mhoon sil	8.9	0.78	0.064	8.21	366
9	Mhoon sil	15.3	1.38	0.068	4.93	233
10	Mhoon sicl	29.9	2.07	0.095	4.59	242
11	Mhoon sic	43.4	2.27	0.105	4.63	336
12	Sharkey c	60.5	3.66	0.175	4.78	362
Av. 1-12		21.9	1.56	0.081	5.44	271
13	Cypremort sil	12.7	1.18	0.062	5.25	33
14	Baldwin sil	16.1	1.80	0.089	4.94	48
15	Baldwin sil	16.1	1.55	0.071	4.58	82
16	Baldwin sic	42.0	2.17	0.125	5.76	30
17	Jeanerette sil	25.2	1.61	0.114	7.08	105
18	Jeanerette sil	21.9	1.58	0.110	6.96	132
19	Jeanerette sil	20.6	3.32	0.131	3.95	451
20	Jeanerette sil	14.8	2.42	0.114	4.71	178
21	Iberia sil	20.0	1.79	0.108	6.03	84
22	Iberia sil	24.1	2.40	0.196	8.17	90
23	Patoutville sil	15.2	1.27	0.078	6.14	15
24	Patoutville sil	15.2	1.27	0.069	5.43	10
25	Richland sil	19.0	2.37	0.115	4.85	27
26	Richland sil	20.3	1.76	0.098	5.57	31
27	Richland sil	16.5	1.38	0.094	6.81	37
28	Olivier sil	17.3	2.12	0.115	5.42	68
Av. 13-28		19.8	1.85	0.106	5.73	89

¹Avail. P extracted with 0.1 N HCl / .03 N NH₄F at 1:20 ratio.

Table 8. Relationship between available, exchangeable and total potassium contents of Alluvial soils and Older Alluvial or Terrace soils.

Exp. Loc. No.	Percentage Avail. K of Exch. K ¹	Percentage Avail. K of Total K ¹	Percentage Exch. K of Total K	Ppm. Exch. K per % Clay
1	98.9	0.53	0.53	8.3
2	85.0	0.47	0.56	11.2
3	78.2	0.42	0.53	7.4
4	73.0	0.48	0.66	13.1
5	92.1	0.60	0.65	7.1
6	91.8	0.37	0.40	5.3
7	78.7	0.62	0.79	5.8
8	87.7	0.30	0.34	7.3
9	108.3	0.36	0.33	4.7
10	72.3	0.50	0.69	5.1
11	75.9	1.16	1.53	6.9
12	53.2	1.42	2.67	9.7
Av. 1-12	82.9	0.60	0.81	7.7
13	102.2	0.29	0.29	3.6
14	93.8	0.34	0.37	4.0
15	86.8	0.40	0.46	4.7
16	77.1	0.79	1.03	4.8
17	96.3	0.55	0.57	4.3
18	90.9	0.53	0.58	4.0
19	105.4	0.47	0.44	2.7
20	94.1	0.67	0.71	5.7
21	98.5	0.41	0.42	3.4
22	116.4	0.71	0.61	3.0
23	89.3	0.61	0.69	5.5
24	94.0	0.37	0.40	3.3
25	83.7	0.57	0.68	5.2
26	85.5	0.65	0.76	5.4
27	82.1	0.50	0.61	5.1
28	86.6	0.41	0.47	3.9
Av. 13-28	92.7	0.52	0.57	4.3

¹Avail. K extracted with 0.1 N HCl at 1:20 soil to solution ratio.

Table 9. Simple correlation coefficients showing the relationships between some of the chemical and physical properties of the soils studied.

Variable	% O.M.	% Clay	Total K	Exch. K	Exch. Ca	Exch. Mg
Percentage Clay	.702	--	.301	.873	.651	.843
Exchangeable K	.555	.873	.459	--	.559	.769
% K Saturation	-.051	.272	.369	.593	-.202	.044
Avail. K; HCl @ 1:10	.493	.873	.475	.948	--	--
Avail. K; HCl @ 1:20	.529	.893	.480	.975	.595	.776
Avail. K; NH ₄ OAc @ 1:10	.549	.903	.441	.984	--	--
Avail. K; NH ₄ OAc @ 1:20	.546	.901	.441	.987	.540	.747
Avail. Ca; HCl @ 1:20	.530	.395	-.022	.275	.925	.630
Avail. Mg; HCl @ 1:20	.472	.704	.408	.642	.895	.908
Cation Exchange Capacity	.763	.858	.238	.722	.944	.921
% Base Saturation	.032	.058	.398	.106	.661	.531

Least significant r at the 1% level = .478

Least significant r at the 5% level = .374

the available potassium varied from 47 ppm. in Cypremort silt loam to 155 ppm. in Baldwin silty clay with an average of 77 ppm. Wyatt and Patrick (141) found that the available potassium by this method varied from 30 to 164 ppm. in this group of soils. Available potassium extracted with 1.0 N ammonium acetate at the 1:20 ratio varied from 54 ppm. in Moon silt loam to 406 ppm. in Sharkey clay with an average of 134 ppm. for the Alluvial soils and from 48 ppm. in Cypremort silt loam to 190 ppm. in Baldwin silty clay with an average of 81 ppm. for the Terrace soils. Available potassium extracted by any method studied was higher in the Alluvial soils than in the Older Alluvial or Terrace soils. Worsham and Sturgis (140) also found a wide variation in the availability of native potassium in soils of the lower Mississippi delta.

Exchangeable potassium varied from 65 to 585 ppm. with an average of 164 ppm. in the Alluvial soils and from 46 to 201 ppm. with an average of 85 ppm. in the Older Alluvial or Terrace soils. Driskell (35) found that the exchangeable potassium in five major soil series of the Older Alluvial or Terrace soil group varied from 39 to 195 ppm. with an average of 101 ppm. Data in Table 8 show that available potassium extracted with 0.1 N HCl at the 1:20 soil to solution ratio was 82.9 and 92.7 per cent of the exchangeable potassium in the Alluvial and Older Alluvial or Terrace soils, respectively. The significant linear regression curve in Figure 1 and correlation coefficient in Table 9 show the association between available potassium and exchangeable potassium. Available potassium and exchangeable potassium were highly correlated with percentage clay in the soils.

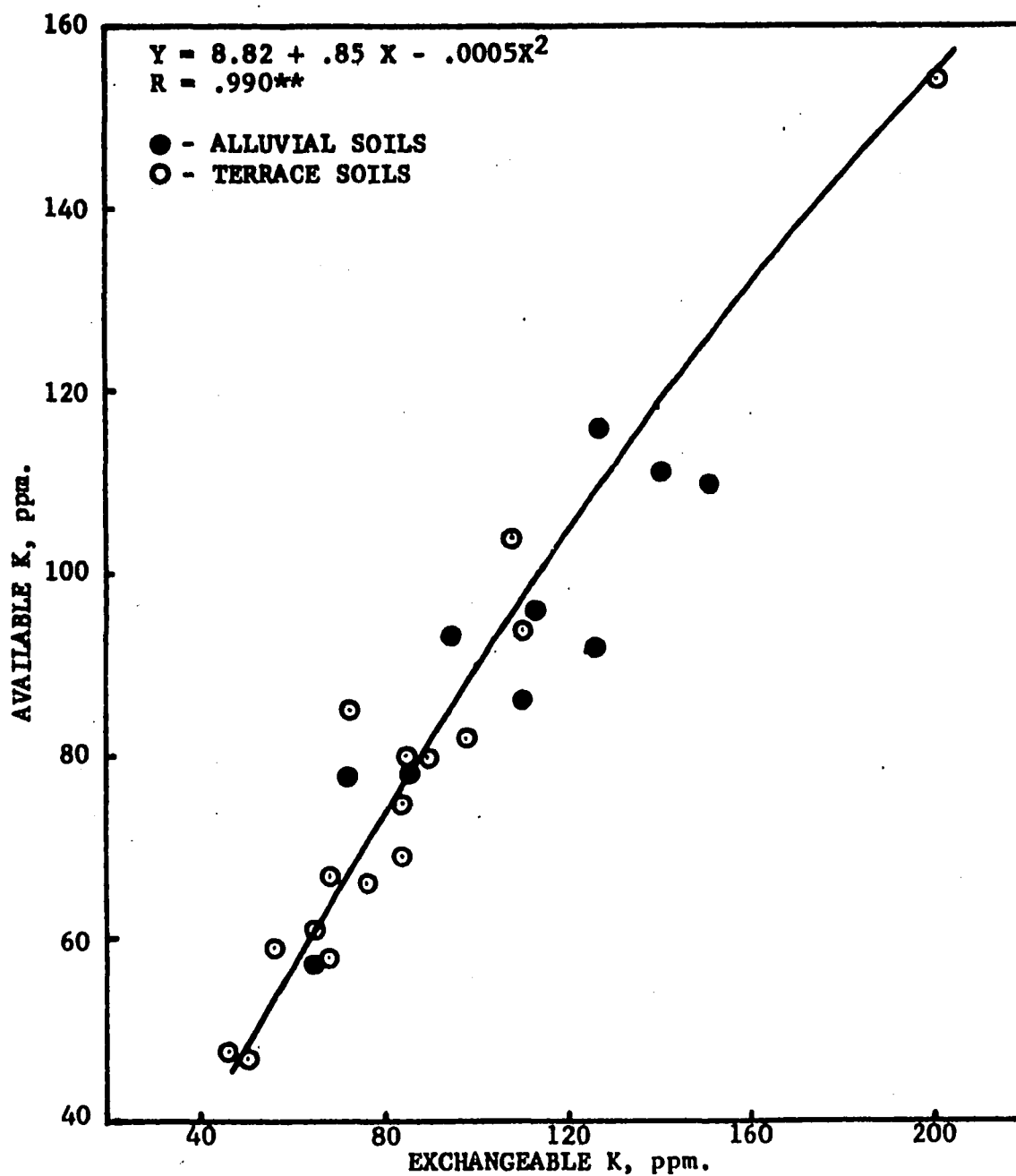


Figure 1. Relationship between exchangeable K and available K extracted with 0.1N HCL at 1:20 soil to solution ratio.

Figure 2 shows the relationship between exchangeable potassium and percentage clay.

Total potassium content of the soils varied from 1.76 per cent in Yahola silt loam to 2.19 per cent in Moon silty clay loam and in Sharkey clay with an average of 2.00 per cent for the Alluvial soils. Total potassium varied from 1.20 per cent in Jeanerette silt loam and in Iberia silt loam to 1.95 per cent in Baldwin silty clay. The average for the Older Alluvial or Terrace soils was 1.49 per cent. Golden (44) found that Commerce, Yahola, Richland, Jeanerette and Baldwin soils contained 1.80, 1.68, 1.25, 1.69 and 1.74 per cent total potassium, respectively. Holmes and Hearn (60) reported that the Robinsonville, Sharkey and Miller soils contained as high as 2.48, 2.67 and 3.04 per cent total K_2O , respectively. Data in Table 8 show that available and exchangeable potassium were 0.60 and 0.81 per cent, respectively, of the total potassium in the Alluvial soils. Available and exchangeable potassium were 0.52 and 0.57 per cent, respectively, of the total potassium in the Older Alluvial or Terrace soils. Figure 3 shows that the association between total potassium and exchangeable potassium in the Alluvial and Older Alluvial or Terrace soils was barely significant. A similar association was found between total potassium and available potassium in the soils. Neidig and McDole (89) concluded that total analysis of soils for potassium was of little practical value in estimating crop yield.

Percentage potassium saturation varied from 1.1 to 2.9 per cent, with an average of 1.9 per cent for the Alluvial soils and from 0.5 to 2.2 per cent with an average of 1.3 per cent for the Older Alluvial or Terrace soils. A non-significant correlation was obtained between

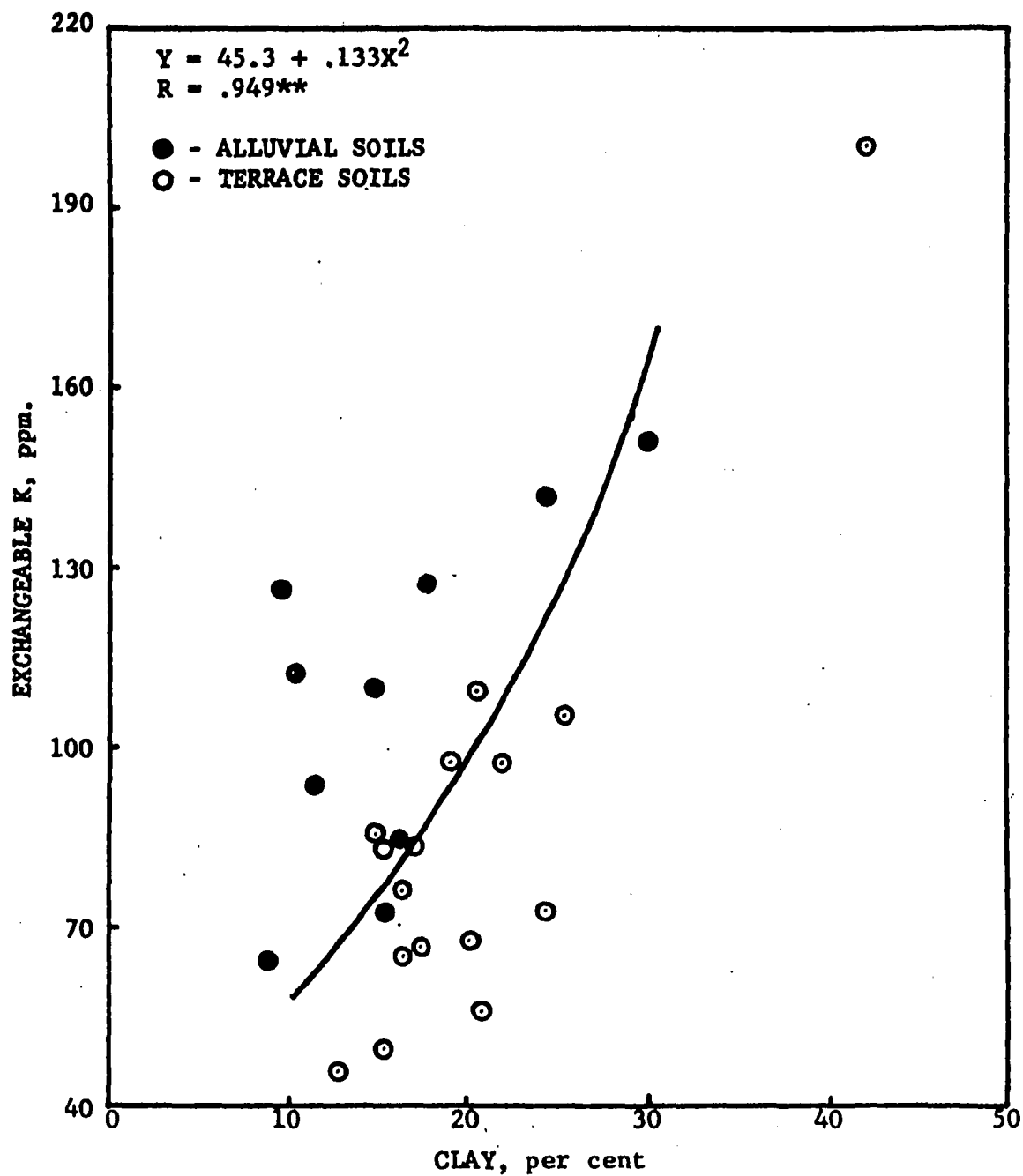


Figure 2. Relationship between exchangeable K and clay contents of the soils.

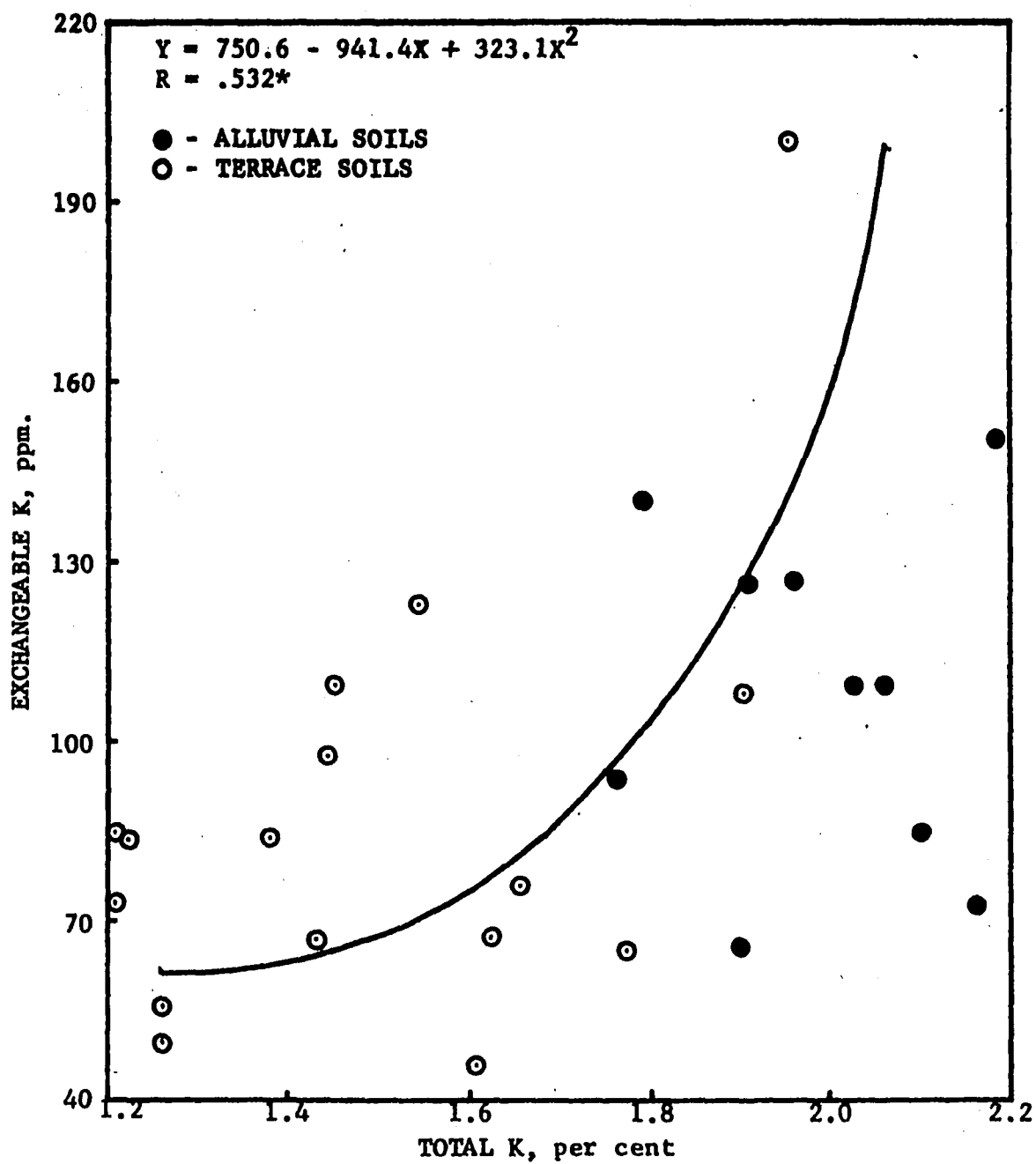


Figure 3. Relationship between exchangeable K and total K contents of the soils.

percentage potassium saturation and total potassium. A significant positive correlation (.593) was obtained between percentage potassium saturation and exchangeable potassium.

Calcium content of the soils

Data on calcium content of the soils are shown in Table 3. Available calcium extracted with 0.1 N hydrochloric acid and with 1.0 N ammonium acetate was slightly higher at the 1:20 than at the 1:10 soil to solution ratio. The ammonium acetate solution extracted slightly less calcium than the hydrochloric acid solution at either ratio. Available calcium extracted by the methods used was higher in the Alluvial soils than in the Older Alluvial or Terrace soils. Available calcium extracted with 0.1 N hydrochloric acid at 1:20 ratio varied from 1174 ppm. in Commerce silt loam to 5805 ppm. in Sharkey clay with an average of 2672 ppm. for the Alluvial soils. Available calcium varied from 284 ppm. in Richland silt loam to 10,420 ppm. in Iberia silt loam with an average of 2408 ppm. for the Older Alluvial or Terrace soils.

Exchangeable calcium varied from 1261 to 6740 ppm. with an average of 2769 ppm. in the Alluvial soils and from 547 to 6044 ppm. with an average of 2212 ppm. in the Older Alluvial or Terrace soils. Highly significant correlation coefficients (Table 9) were obtained between exchangeable calcium and available calcium extracted by the different methods. A positive correlation (.559) was obtained between exchangeable calcium and exchangeable potassium. In certain soils, particularly in the Iberia and Yahola series, low amounts of exchangeable potassium occurred with high amounts of exchangeable calcium. The field results with the Iberia and Jeanerette soils show responses

to fertilizer potassium (125). Response of sugar cane to fertilizer potassium on Olivier and Richland soils can be expected due to low amounts of exchangeable potassium in these soils. Response to fertilizer potassium on Jeanerette and Iberia soils can be expected due to low amounts of exchangeable potassium and high amounts of exchangeable calcium which may interfere with the absorption of potassium.

Percentage calcium saturation varied from 56.4 to 85.5 per cent with an average of 64.5 per cent in the Alluvial soils and from 26.0 to 83.2 per cent with an average of 51.6 per cent in the Older Alluvial or Terrace soils.

Magnesium content of the soils

Data on magnesium content of the soils are shown in Table 4. Available magnesium extracted with 0.1 N hydrochloric acid and with 1.0 N ammonium acetate was slightly higher at the 1:20 than at the 1:10 soil to solution ratio. The ammonium acetate solution extracted less magnesium than the hydrochloric acid solution at either ratio. Available magnesium extracted with 0.1 N hydrochloric acid at 1:20 ratio varied from 331 ppm. in Commerce silt loam to 1565 ppm. in Sharkey clay with an average of 771 ppm. for the Alluvial soils. Available magnesium varied from 169 ppm. in Olivier silt loam to 1089 ppm. in Jeanerette silt loam with an average of 533 ppm. in the Older Alluvial or Terrace soils.

Exchangeable magnesium varied from 274 to 1546 ppm. with an average of 594 ppm. in the Alluvial soils and from 151 to 848 ppm. with an average of 448 ppm. for the Older Alluvial or Terrace soils. Highly significant correlation coefficients (Table 9) were obtained between

exchangeable magnesium and available magnesium extracted by the different methods. The Alluvial soils generally contained more exchangeable and available magnesium than the Older Alluvial or Terrace soils.

Percentage magnesium saturation varied from 12.9 to 28.6 per cent with an average of 22.5 per cent for the Alluvial soils and from 9.5 to 26.2 per cent with an average of 19.0 per cent for the Older Alluvial or Terrace soils. Correlation coefficients shown in Table 9 indicate that the potassium content of the soils studied was more closely related to the magnesium than the calcium content. However, this was not the case in the Jeanerette and Iberia soils.

Sodium content of the soils

Data on sodium content of the soils are shown in Table 5. Available sodium extracted with 0.1 N hydrochloric acid and with 1.0 N ammonium acetate was higher at the 1:20 than at the 1:10 soil to solution ratio. The ammonium acetate solution extracted less sodium than the hydrochloric acid solution at either ratio. The average percentage sodium saturation was 0.9 per cent in the Alluvial soils and 1.2 per cent in the Older Alluvial or Terrace soils.

Cation exchange capacity of the soils

Cation exchange capacity, exchangeable hydrogen content and pH values of the soils are presented in Table 6. Cation exchange capacity in the Alluvial soils varied from 9.58 to 50.89 with an average of 21.26 me. per 100 grams of dry soil. Cation exchange capacity in the Older Alluvial or Terrace soils varied from 9.09 to 36.32 with an average of 19.05 me. per 100 grams of dry soil. Driskell (35) found that the average cation exchange capacity of five major soil types of the Older Alluvial or Terrace soils was 17.3 me. per 100 grams of soil.

Wyatt and Patrick (141) reported that the cation exchange capacity of Cypremort, Baldwin and Iberia soils was 11.9, 19.0 and 22.8 me. per 100 grams, respectively.

Percentage base saturation in the Alluvial soils was composed of 1.9 per cent potassium, 64.5 per cent calcium, 22.5 per cent magnesium and 0.9 per cent sodium or a total of 89.8 per cent. Percentage base saturation in the Older Alluvial or Terrace soils was composed of 1.3 per cent potassium, 51.6 per cent calcium, 19.0 per cent magnesium, 1.2 per cent sodium or a total of 73.0 per cent. Correlation coefficients in Table 9 show that the exchangeable potassium was closely associated with the cation exchange capacity, but the total potassium was not associated with the cation exchange capacity.

In the Alluvial soils, pH varied from 5.6 in Commerce silt loam to 7.3 for Yahola silt loam while in the Older Alluvial and Terrace soils it varied from 4.8 for Baldwin silty clay to 7.3 for Jeanerette silt loam and Iberia silt loam. A wide variation in soil reaction occurred among some of the soil types at different experimental locations. It is apparent that a definite need for liming the soil exists in some areas. The pH varied from 4.9 to 5.5 in the Cypremort, Olivier and Richland soils.

Physical properties and available phosphorus content of the soils

Clay, organic matter, total nitrogen, and available phosphorus contents of the soils are presented in Table 7. Wide variations were found in clay content of the Alluvial soils. Shuker (116) studied the physical properties of the Cypremort, Baldwin and Iberia series which are among the Older Alluvial or Terrace soil group. He found that poor internal soil drainage and poor soil structure commonly occur

in these soils. It was found that available and exchangeable cations increased significantly with an increase in clay content of the soils.

The organic matter content of the Alluvial soils varied from 0.78 per cent in Moon silt loam to 3.66 per cent in Sharkey clay. Organic matter content in the Older Alluvial or Terrace soils varied from 1.18 per cent in Cypremort silt loam to 3.32 per cent in Jeanerette silt loam. A significant positive correlation was obtained between organic matter content and clay content in the soils. This relationship is shown graphically in Figure 4. Wyatt and Patrick (141) obtained a similar relationship between organic matter and clay contents of Cypremort, Baldwin and Iberia soils. The average percentage organic matter for each per cent clay was 0.081 in Alluvial soils and 0.099 in Older Alluvial or Terrace soils. There were, however, some low values in each group. Sturgis (124) pointed out that soils must contain as much as 0.08 per cent soil organic matter for each per cent of clay to preserve the physical conditions necessary for crops to efficiently use applied fertilizers. Although the average percentage organic matter for each per cent clay in each soil group was above 0.08, the organic matter content at some of the locations was low and consequently the soils were in poor physical condition.

Total nitrogen content varied from 0.041 to 0.175 per cent in the Alluvial soils and from 0.062 to 0.196 per cent in the Older Alluvial or Terrace soils. The average percentage of total nitrogen in the soil organic matter was 5.44 per cent in the Alluvial soils and 5.73 per cent in the Older Alluvial or Terrace soils. It is noted that the Older Alluvial or Terrace soils were lower in exchangeable bases but higher in organic matter content than the Alluvial soils.

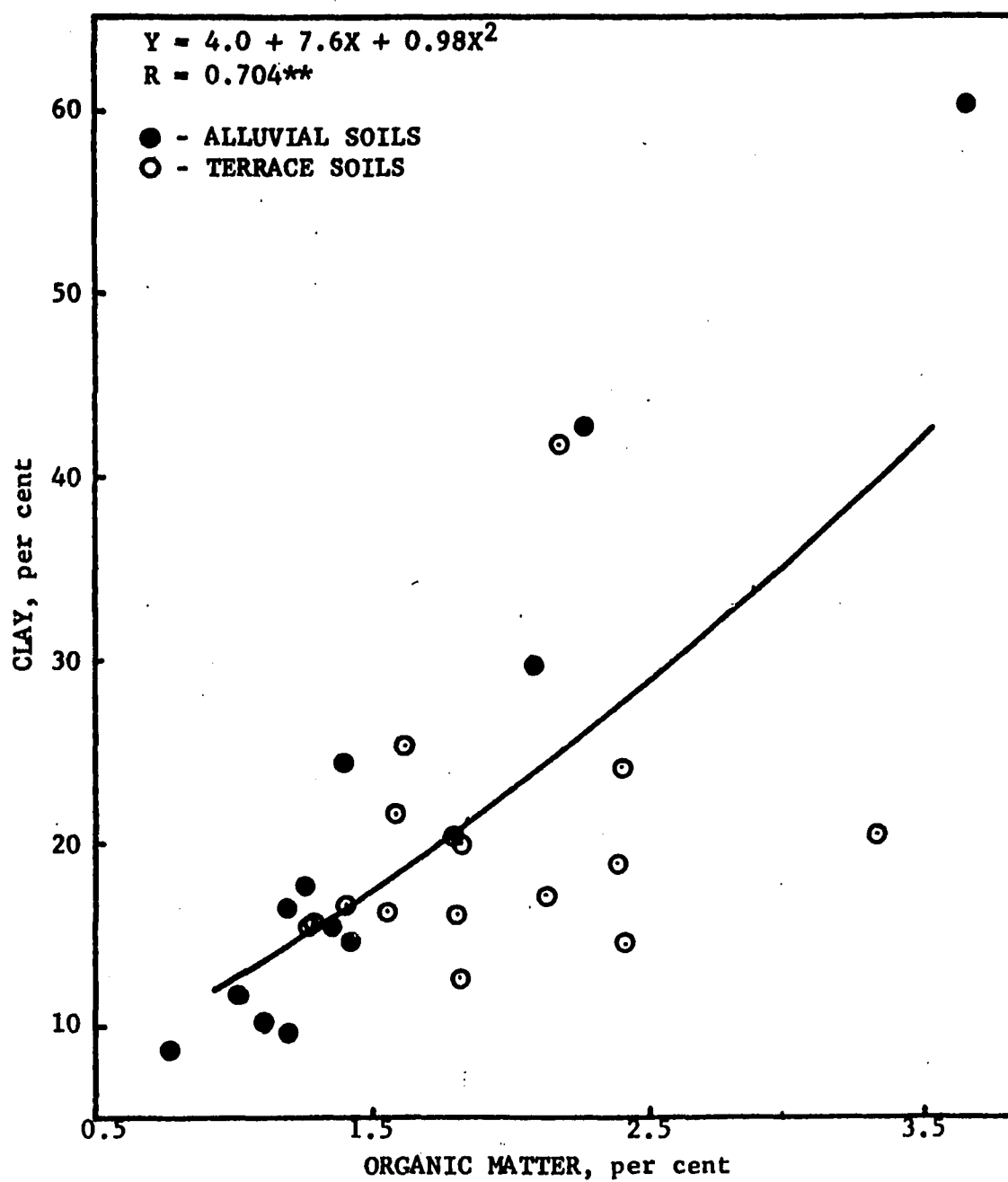


Figure 4. Relationship between clay and organic matter contents of the soils.

Data on available soil phosphorus are presented in Table 9 to complete the information on the fertility status of soils studied. Byrnside and Sturgis (26) made a more complete study of the soil phosphorus as related to response of sugar cane to fertilizer phosphorus.

Sugar Cane Yield in Fertilizer Experiments

Sugar cane yield data obtained from 49 fertilizer experiments at the 28 experimental locations are presented in Tables 10 and 11. Since the fertilizer treatments were increased to higher rates in some of the experiments in 1960, yield data obtained from 1954 to 1960 are reported in Table 10 and yield data obtained from 1960 to 1963 are reported in Table 11. The type of analysis applied to the yield data obtained in each experiment is shown in Table 12. One analysis of variance was calculated for all fertilizer treatments to obtain a least significant difference for comparing the yield from any two fertilizer treatments. Another analysis of variance was calculated for the yield data from only the 3 x 2 x 2 factorial with N-P-K treatments. The factorial analysis was used to determine the significance of the yield responses from the individual N, P and K fertilizers and their interactions.

Significant differences in the yield of sugar cane due to fertilizer treatments were obtained in 17 of the 22 experiments conducted on Alluvial soils and in 20 of the 27 experiments conducted on the Older Alluvial or Terrace soils. Byrnside and Sturgis (26) found that the Older Alluvial or Terrace soils were more responsive to fertilizer phosphorus and potassium than the Alluvial soils.

Table 10. Effect of fertilizers on yield of plant and stubble sugar cane in tons per acre in experiments conducted from 1954 to 1960.

Fertilizer Treatment ¹ N-P ₂ O ₅ -K ₂ O Lbs./A.	1-Edgefield	2-Smithfield	3-Smithfield	5-Little Texas				
	Yahola sil	Commerce loam	Commerce sil	Moon loam				
	CP 52-68	CP 36-105	CP 36-105	CP 36-105				
	Plant 1959	Pl.54 St.56	Pl.59 St.60	Pl.54	St.55	St.56		
0-0-0	24.2	25.3 13.6	25.1 20.6	20.4	21.4	12.1		
40-0-0	24.8	30.7 --	28.7 --	30.2	--	--		
40-0-60	23.9	31.4 --	27.6 --	30.2	--	--		
40-40-0	23.4	-- --	30.3 --	--	--	--		
40-40-60	22.2	32.2 --	26.9 --	32.4	--	--		
60-0-0	24.4	31.7 --	28.9 --	28.1	--	--		
60-0-60	28.1	33.3 --	29.8 --	28.5	--	--		
60-40-0	24.9	-- --	27.1 --	--	--	--		
60-40-60	26.9	31.7 --	28.3 --	29.5	--	--		
80-0-0	24.3	33.1 18.5	28.1 22.7	27.2	26.2	18.1		
80-0-60	24.7	33.1 22.1	31.2 24.7	30.2	25.6	18.9		
80-40-0	24.3	-- --	28.1 25.4	--	--	--		
80-40-60	26.8	31.4 19.4	27.3 24.8	29.4	26.4	20.9		
100-0-0	--	-- 20.6	-- 25.2	--	28.0	20.4		
100-0-60	--	-- 22.7	-- 26.7	--	28.7	21.3		
100-40-0	--	-- --	-- 24.5	--	--	--		
100-40-60	--	-- 23.3	-- 24.4	--	28.0	22.3		
120-0-0	--	-- 22.8	-- 25.4	--	27.7	18.7		
120-0-60	--	-- 22.7	-- 25.4	--	28.2	18.9		
120-40-0	--	-- --	-- 24.5	--	--	--		
120-40-60	--	-- 22.5	-- 26.5	--	29.0	23.9		
L.S.D. 5%	N.S.	4.9 1.9	3.3 N.S.	5.1	2.7	1.6		

¹The lower rates of N were applied to plant cane.

Table 10. Continued.

Fertilizer Treatment ¹ N-P ₂ O ₅ -K ₂ O lbs./A.	6-L. Texas Moon sil CP 36-105 St.58 St.59		8-Smithfld. Moon loam CP 36-105 Stubble '58		14-Alice B Baldwin sil CP 44-101 Pl.56 St.57 St.58		16-O'Neil Baldwin sic CP 44-101 Pl.58 St.59 St.60		
0-0-0	16.9	14.4	18.7	25.3	20.3	17.6	15.8	17.6	11.3
40-0-0	--	--	--	27.7	--	--	19.8	--	--
40-0-60	--	--	--	28.7	--	--	20.1	--	--
40-40-0	--	--	--	--	--	--	20.6	--	--
40-40-60	--	--	--	32.4	--	--	22.0	--	--
60-0-0	--	--	--	27.5	--	--	19.6	--	--
60-0-60	--	--	--	29.6	--	--	22.2	--	--
60-40-0	--	--	--	--	--	--	20.7	--	--
60-40-60	--	--	--	30.6	--	--	22.4	--	--
80-0-0	26.0	20.4	23.1	29.7	24.3	21.3	21.1	26.9	15.8
80-0-60	28.4	21.1	24.4	30.3	30.3	24.9	21.0	25.3	17.0
80-40-0	26.6	22.7	24.7	--	--	--	23.2	26.7	17.8
80-40-60	28.0	23.6	25.4	30.1	28.9	25.3	23.0	31.0	18.9
100-0-0	25.6	19.8	26.5	--	28.2	22.4	--	26.4	14.8
100-0-60	27.0	21.4	25.4	--	28.7	23.9	--	28.4	17.5
100-40-0	27.9	23.7	26.6	--	--	--	--	27.3	17.0
100-40-60	29.3	23.4	25.0	--	27.1	24.7	--	33.7	19.2
120-0-0	25.4	19.0	24.1	--	27.7	21.3	--	28.2	16.0
120-0-60	26.6	19.8	25.8	--	30.7	23.8	--	31.8	18.1
120-40-0	28.5	24.0	23.8	--	--	--	--	30.3	18.9
120-40-60	29.0	24.3	27.1	--	24.5	24.5	--	30.2	20.8
L.S.D. 5%	2.0	3.7	4.2	2.9	3.0	N.S.	2.8	5.7	1.8

¹The lower rates of N were applied to plant cane.

Table 10. Continued.

Fertilizer Treatment ¹ N-P ₂ O ₅ -K ₂ O lbs./A.	17-Alice B Jeanerette sil NCO 310 Pl.59 St.60	21-Katy Iberia sil CP 36-13 Pl.55 St.56	22-C. Grove Iberia sil CP 44-154 Plant 1956	23-Vaufrey Patout. sil CP 44-101 Plant 1955	24-Vaufrey Patout. sil CP 44-101 Plant 1956
0-0-0	27.4	22.0	18.5 14.9	22.7	18.0 18.1
40-0-0	31.4	--	21.8 --	26.7	20.6 21.8
40-0-60	31.0	--	22.5 --	26.8	21.5 22.3
40-40-0	31.1	--	-- --	--	-- --
40-40-60	32.8	--	23.5 --	29.8	26.7 24.4
60-0-0	33.1	--	23.1 --	25.4	23.1 23.0
60-0-60	31.6	--	22.2 --	25.8	23.7 25.4
60-40-0	31.8	--	-- --	--	-- --
60-40-60	31.3	--	26.7 --	26.6	28.6 27.7
80-0-0	31.7	28.6	23.8 18.4	25.6	24.0 24.5
80-0-60	32.6	28.4	24.3 18.6	27.7	26.3 23.9
80-40-0	32.3	26.9	-- --	--	-- --
80-40-60	36.1	30.6	23.4 18.7	27.3	25.6 25.8
100-0-0	--	28.8	-- 19.0	--	-- --
100-0-60	--	29.4	-- 20.3	--	-- --
100-40-0	--	26.2	-- --	--	-- --
100-40-60	--	31.7	-- 20.8	--	-- --
120-0-0	--	26.7	-- 20.8	--	-- --
120-0-60	--	30.3	-- 25.5	--	-- --
120-40-0	--	29.2	-- --	--	-- --
120-40-60	--	28.3	-- 22.2	--	-- --
L.S.D. 5%	N.S.	4.5	3.2 1.7	2.9	5.2 1.7

¹The lower rates of N were applied to plant cane.

Table 10. Continued.

Fertilizer Treatment ¹ N-P ₂ O ₅ -K ₂ O lbs./A.	25-Young Ind. Richland sil NCO 310 Pl.'54	26-Young Ind. Richland sil CP 44-101 Plant 1956	27-Billeaud Richland sil CP 44-155 Stubble '57	28-Young Ind. Oliver sil CP 44-101 Pl.'59	St.'60
0-0-0	18.9	12.3	15.2	17.6	25.0 19.0
40-0-0	21.4	--	16.3	--	24.1 --
40-0-60	24.5	--	17.0	--	24.7 --
40-40-0	--	--	--	--	25.7 --
40-40-60	26.6	--	17.4	--	27.6 --
60-0-0	24.0	--	17.8	--	26.3 --
60-0-60	25.9	--	18.3	--	25.8 --
60-40-0	--	--	--	--	25.6 --
60-40-60	28.8	--	18.8	--	26.5 --
80-0-0	23.3	16.4	19.7	22.7	30.7 20.1
80-0-60	25.0	17.9	20.2	21.5	30.9 21.9
80-40-0	--	--	--	22.3	27.5 20.7
80-40-60	27.6	20.9	21.3	23.5	29.0 23.9
100-0-0	--	19.6	--	20.3	-- 20.6
100-0-60	--	23.8	--	22.9	-- 24.0
100-40-0	--	--	--	20.8	-- 20.2
100-40-60	--	26.1	--	23.8	-- 23.8
120-0-0	--	22.8	--	--	-- 23.1
120-0-60	--	26.9	--	--	-- 20.0
120-40-0	--	--	--	--	-- 23.9
120-40-60	--	28.2	--	--	-- 23.7
L.S.D. 5%	1.3	1.6	0.7	1.9	3.3 3.4

¹The lower rates of N were applied to plant cane.

Table 11. Effect of fertilizers on yield of plant and stubble sugar cane in tons per acre in experiments conducted from 1960 to 1963.

Fertilizer Treatment ¹ N-P ₂ O ₅ -K ₂ O Lbs./A.	4-Alma Commerce sil		7-Harang Moon sil		9-Little Texas Moon loam			10-Pecan Tree Moon sil	
	CP 52-68		CP 52-68		CP 52-68			CP 44-101	
	Pl.62	St.63	Stubble 63		Pl.60	St.61	St.62	St.60	St.61
0-0-0	28.0	24.8	36.8		28.5	25.6	14.7	22.8	21.3
40-0-0	27.1	--	--		33.4	--	--	--	--
40-0-80	27.9	--	--		33.0	--	--	--	--
40-40-0	28.6	--	--		32.4	--	--	--	--
40-40-80	28.5	--	--		33.1	--	--	--	--
80-0-0	29.6	28.4	39.5		32.9	32.0	18.8	32.6	27.9
80-0-80	29.4	29.2	40.3		35.5	31.8	16.2	32.3	26.2
80-40-0	27.0	28.7	43.1		34.7	33.0	18.0	30.3	28.2
80-40-80	28.2	29.7	42.5		34.3	33.4	17.5	31.9	28.4
120-0-0	27.5	29.6	42.1		32.9	30.2	17.1	30.8	25.5
120-0-80	29.5	31.0	40.4		34.4	34.5	19.0	32.0	27.8
120-40-0	27.1	27.4	41.4		34.4	33.9	18.3	32.0	28.7
120-40-80	30.1	29.2	44.7		35.6	34.3	19.5	32.9	28.6
160-0-0	--	26.1	41.1		--	32.0	19.2	30.4	26.5
160-0-80	--	29.9	42.2		--	34.9	19.8	32.0	26.5
160-40-0	--	29.3	44.7		--	33.6	20.9	34.6	28.2
160-40-80	--	29.9	44.7		--	35.5	21.8	33.6	29.7
L.S.D. 5%	N.S.	2.6	3.8		2.1	2.5	N.S.	3.1	3.9

¹The lower rates of N were applied to plant cane.

Table 11. Continued.

Fertilizer Treatment ¹ N-P ₂ O ₅ -K ₂ O lbs./A.	11-Caldwell	12-Pecan Tree		13-Alice B	15-Alice B	
	Moon sic	Sharkey Clay		Cypremort sil	Baldwin sil	
	CP 52-68	CP 44-101		CP 52-68	NCO 310	
	Stubble '63	Pl.'62	St.'63	Stubble '61	Pl.'62	St.'63
0-0-0	29.3	21.2	24.4	27.9	35.8	27.3
40-0-0	--	21.9	--	--	39.6	--
40-0-80	--	18.8	--	--	35.0	--
40-40-0	--	21.4	--	--	37.1	--
40-40-80	--	22.3	--	--	37.6	--
80-0-0	38.3	22.1	27.8	30.2	36.4	39.1
80-0-80	36.7	22.3	26.3	31.9	38.8	34.6
80-40-0	36.5	22.5	29.7	29.7	40.1	38.8
80-40-80	38.6	23.7	29.6	31.0	39.3	34.2
120-0-0	35.0	22.6	29.3	31.5	38.3	35.6
120-0-80	38.1	22.8	32.2	34.2	37.0	38.4
120-40-0	37.9	23.0	31.4	34.7	38.4	37.1
120-40-80	37.7	24.1	31.3	33.3	39.8	39.2
160-0-0	37.1	--	30.6	31.8	--	38.6
160-0-80	39.8	--	30.9	35.0	--	40.0
160-40-0	40.7	--	30.7	29.4	--	38.2
160-40-80	41.3	--	33.5	33.8	--	40.8
L.S.D. 5%	3.9	N.S.	3.1	3.6	N.S.	3.0

¹The lower rates of N were applied to plant cane.

Table 11. Continued.

Fertilizer Treatment ¹ N-P ₂ O ₅ -K ₂ O lbs./A.	18-St. John Jeanerette sil CP 52-68 Plant 1963	19-Patout Jeanerette sil CP 52-68 Stubble 1961	20-Patout Jeanerette sil CP 52-68 Pl.'62 St.'63	28-Young's Ind. Olivier sil CP 44-101 Stubble 1961
0-0-0	37.3	23.9	22.3 21.9	22.0
40-0-0	38.1	--	22.4 --	--
40-0-80	38.0	--	23.2 --	--
40-40-0	38.7	--	21.1 --	--
40-40-80	39.3	--	21.9 --	--
80-0-0	39.0	24.0	22.5 28.2	22.2
80-0-80	38.2	24.3	22.6 30.7	26.5
80-40-0	38.5	25.6	20.3 30.4	25.0
80-40-80	36.5	26.4	24.9 32.5	28.8
120-0-0	36.9	24.1	21.0 31.6	23.0
120-0-80	38.5	30.7	21.3 32.1	27.6
120-40-0	39.1	25.8	22.6 29.7	24.3
120-40-80	35.2	27.0	22.9 32.1	29.7
160-0-0	--	26.5	-- 29.5	25.5
160-0-80	--	28.0	-- 32.9	24.5
160-40-0	--	24.9	-- 33.0	26.1
160-40-80	--	27.7	-- 34.4	26.5
L.S.D. 5%	N.S.	N.S.	N.S. 2.9	N.S.

¹The lower rates of N were applied to plant cane.

Table 12. Analyses of variance for yield data of sugar cane, stubble C.P. 52-68, on Mhoon silt loam at Little Texas Plantation (location 9) in 1961.

Analysis of Variance with All Fertilizer Treatments				
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F Value
Replication	2	3.85	1.93	0.83
Treatment	15	353.96	23.60	10.17**
Error	30	69.58	2.32	
Total	47	427.39		

L.S.D. for comparing two treatments = $(2.32 \times 2/3)^{\frac{1}{2}} \times 2.042 = 2.5$ T/A.

Analysis of Variance for 3 x 2 x 2 Factorial with NPK Treatments

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F Value
Replication	2	2.61	1.31	0.74
N	2	12.28	6.14	3.45*
P	1	17.29	17.29	9.71**
K	1	23.90	23.90	13.43**
N x P	2	0.71	0.35	0.20
N x K	2	9.96	4.98	2.80
P x K	1	4.32	4.32	2.43
N x P x K	2	8.00	4.00	2.25
Error	22	39.26	1.78	
Total	35	118.33		

L.S.D. for comparing two levels of N = $(1.78 \times 2/12)^{\frac{1}{2}} = 1.1$ T/A.

L.S.D. for comparing two levels of P or K = $(1.78 \times 2/18)^{\frac{1}{2}} = 0.9$ T/A.

* Significant at 5%; **Significant at 1%.

Response of Sugar Cane to Fertilizer Potassium

Sugar cane yield responses to fertilizer potassium obtained in experiments on the Alluvial soils and Older Alluvial or Terrace soils are presented in Tables 13 and 14, respectively. Yield responses were determined in each experiment by difference between yield on plots with applied potassium and yield of plots without applied potassium at each of the three levels of applied nitrogen and the two levels of applied phosphorus. Since the factorial analysis of the yield data from each experiment revealed that significant interactions among fertilizer treatments occurred in less than 5 per cent of the experiments, the responses to potassium were recorded as an average of the differences between N and N-K treatments and between N-P and N-P-K treatments at the three levels of N. The responses to potassium were not highly consistent among the levels of N and P; so the responses were also recorded as determined by a method of comparison. By the comparative method, the yield responses from fertilizer N, P and K in each experiment were carefully examined and the response due to potassium at the N and P levels which appeared to be most representative of the experiment was recorded as the response to potassium. The fertilizer treatment from which the response to potassium was obtained in each experiment is shown in Tables 13 and 14. Although a human error may be involved in the method of comparison, it is felt that the responses determined by this method with experiments of long duration are of more practical value than by the factorial method in which only average responses are considered.

Table 13. Sugar cane yield responses due to fertilizer potassium on Alluvial soils by the factorial and comparative methods of analysis.

Exp. Loc. No.	Soil Type	Avail. Soil K	Age of Cane	Yield without Fert.	Factorial Method		Comparative Method				
					Yield without K ₂ O	Resp. to K ₂ O	Treat. without K ₂ O	Yield without K ₂ O	Treat. with K ₂ O	Yield with K ₂ O	Resp. to K ₂ O
		ppm.		T/A.	T/A.	T/A.	N-P ₂ O ₅ -K ₂ O lbs./A.	T/A.	N-P ₂ O ₅ -K ₂ O lbs./A.	T/A.	T/A.
1	Yahola sil	93	Fl.	24.2	24.4	1.1	80-40-0	24.3	80-40-60	26.8	2.5
2	Commerce 1	96	Fl.	25.3	31.8	0.8	60-0-0	31.7	60-0-60	33.3	1.6
2	Commerce 1	96	St.	13.6	20.6	1.9*	100-0-0	20.6	100-0-60	22.7 ₂	2.1*
3	Commerce sil	86	Fl.	25.1	28.5	0.0	60-40-0	27.1	60-40-60	28.3	1.2
3	Commerce sil	86	St.	20.6	24.6	0.8	80-0-0	22.7	80-0-60	24.7	2.0
4	Commerce sil	92	Fl.	28.0	27.8	1.1	80-40-0	27.0	80-40-80	28.2	1.2
4	Commerce sil	92	St.	24.8	28.2	1.6*	120-0-0	29.6	120-0-80	31.0	1.4
5	Mhoon 1	117	Fl.	20.4	28.5	1.1	60-0-0	28.1	60-0-60	28.5	0.4
5	Mhoon 1	117	St.	21.4	27.3	0.2	100-0-0	28.0	100-0-60	28.7	0.7
5	Mhoon 1	117	St.	12.1	19.1	0.7	100-0-0	20.4	100-0-60	21.3	0.9
6	Mhoon sil	78	St.	16.9	26.7	1.4*	80-40-0	26.6	80-40-60	28.0	1.4
6	Mhoon sil	78	St.	14.4	21.6	0.7	80-40-0	22.7	80-40-60	23.6	0.9

Table 13. Continued.

Exp. Loc. No.	Soil Type	Avail. Soil K	Age of Cane	Yield with- out Fert.	Factorial Method		Comparative Method				
					Yield without K ₂ O	Resp. to K ₂ O	Treat. without K ₂ O	Yield without K ₂ O	Treat. with K ₂ O	Yield with K ₂ O	Resp. to K ₂ O
		ppm.		T/A.	T/A.	T/A.	N-P ₂ O ₅ -K ₂ O Lbs./A.	T/A.	N-P ₂ O ₅ -K ₂ O Lbs./A.	T/A.	T/A.
7	Mhoon sil	111	St.	36.8	42.0	0.5	160-40-0	44.7	160-40-80	44.7	0.0
8	Mhoon 1	57	St.	18.7	24.8	0.7	120-40-0	23.8	120-40-60	27.1	3.3
9	Mhoon 1	78	Pl.	28.5	33.5	0.9*	120-40-0	34.4	120-40-80	35.6	1.2
9	Mhoon 1	78	St.	25.6	32.4	1.6	160-40-0	33.6	160-40-80	35.5	1.9
9	Mhoon 1	78	St.	14.7	18.7	0.3	120-40-0	18.3	160-40-80	19.5	1.2
10	Mhoon sicl	110	St.	22.8	31.8	0.7	120-40-0	32.0	120-40-80	32.9	0.9
10	Mhoon sicl	110	St.	21.3	27.5	0.4	160-40-0	28.2	120-40-80	29.7	1.5
11	Mhoon sic	227	St.	29.3	37.6	1.1	160-40-0	40.7	160-40-80	41.3	0.6
12	Sharkey c	311	Pl.	21.2	22.3	0.1	80-0-0	22.1	80-0-80	22.3	0.2
12	Sharkey c	311	St.	24.4	29.9	0.7	160-0-0	30.6	80-0-80	30.9	0.3
Average for Alluvial Soils			Pl.	24.7	29.8	0.7		27.8		29.0	1.2
Average for Alluvial Soils			St.	21.2	25.4	0.9		28.2		29.5	1.3

*Significant at 5% level of probability.

Pl. = Plant cane; St. = Stubble cane.

Table 14. Sugar cane yield responses due to fertilizer potassium on Older Alluvial or Terrace soils by the factorial and comparative methods of analysis.

Exp. Loc. No.	Soil Type	Avail. Soil K	Age of Cane	Yield with- out Fert.	Factorial Method		Comparative Method				
					Yield without K ₂ O	Resp. to K ₂ O	Treat. without K ₂ O	Yield without K ₂ O	Treat. with K ₂ O	Yield with K ₂ O	Resp. to K ₂ O
		ppm.		T/A.	T/A.	T/A.	N-P ₂ O ₅ -K ₂ O lbs./A.	T/A.	N-P ₂ O ₅ -K ₂ O lbs./A.	T/A.	T/A.
13	Cypremort sil	47	St.	27.9	31.2	2.0*	160-0-0	31.8	160-0-80	35.0	3.2
14	Baldwin sil	61	Pl.	25.3	28.3	1.3	60-0-0	27.5	60-0-60	29.6	2.1
14	Baldwin sil	61	St.	20.3	26.7	3.2*	120-0-0	27.7	120-0-60	30.7	3.0
14	Baldwin sil	61	St.	17.6	21.7	2.5	120-0-0	21.3	120-0-60	23.8	2.5
15	Baldwin sil	66	Pl.	35.8	38.3	-0.4	120-40-0	38.4	120-40-80	39.8	1.4
15	Baldwin sil	66	St.	27.3	37.9	0.0	160-40-0	38.2	160-40-80	40.8	2.6
16	Baldwin sic	155	Pl.	15.8	20.8	1.0	60-40-0	20.7	60-40-60	22.4	1.7
16	Baldwin sic	155	St.	17.6	27.7	2.4*	100-0-0	26.4	100-0-60	28.4	2.0
16	Baldwin sic	155	St.	11.3	16.7	1.9*	120-40-0	18.9	120-40-60	20.8	1.9*
17	Jeanerette sil	104	Pl.	27.4	31.9	0.7	80-0-0	31.7	80-0-60	32.6	0.9
17	Jeanerette sil	104	St.	22.0	27.7	2.1*	100-0-0	28.8	100-0-60	29.4	0.6

Table 14. Continued.

Exp. Loc. No.	Soil Type	Avail. Soil K	Age of Cane	Yield with- out Fert.	Factorial Method		Comparative Method				
					Yield without K ₂ O	Resp. to K ₂ O	Treat. without K ₂ O	Yield without K ₂ O	Treat. with K ₂ O	Yield with K ₂ O	Resp. to K ₂ O
		ppm.		T/A.	T/A.	T/A.	N-P ₂ O ₅ -K ₂ O Lbs./A.	T/A.	N-P ₂ O ₅ -K ₂ O Lbs./A.	T/A.	T/A.
18	Jeanerette sil	80	Fl.	37.3	38.4	-0.8	120-0-0	36.9	120-0-80	38.5	1.6
19	Jeanerette sil	59	St.	23.9	25.2	2.2*	160-40-0	24.9	160-40-80	27.7	2.8
20	Jeanerette sil	80	Fl.	22.3	21.7	1.1	40-0-0	22.4	40-0-80	23.2	0.8
20	Jeanerette sil	80	St.	21.9	30.4	2.1*	120-40-0	29.7	120-40-80	32.1	2.4
21	Iberia sil	67	Fl.	18.5	22.9	0.1	40-0-0	21.8	40-0-60	22.5	0.7
21	Iberia sil	67	St.	14.9	19.4	2.1*	100-0-0	19.0	100-0-60	20.3	1.3
22	Iberia sil	85	Fl.	22.7	25.9	0.9	80-0-0	25.6	80-0-60	27.7	2.1
23	Patoutville sil	75	Fl.	18.0	22.6	1.2	80-0-0	24.0	80-0-60	26.3	2.3
24	Patoutville sil	47	Fl.	18.1	23.1	0.8*	60-0-0	23.0	60-0-60	25.4	2.4*

Table 14. Continued.

Exp. Loc. No.	Soil Type	Avail. Soil K	Age of Cane	Yield with- out Fert.	Factorial Method		Comparative Method				
					Yield without K ₂ O	Resp. to K ₂ O	Treat. without K ₂ O	Yield without K ₂ O	Treat. with K ₂ O	Yield with K ₂ O	Resp. to K ₂ O
		ppm.		T/A.	T/A.	T/A.	N-P ₂ O ₅ -K ₂ O lbs./A.	T/A.	N-P ₂ O ₅ -K ₂ O lbs./A.	T/A.	T/A.
25	Richland sil	82	Pl.	18.9	22.9	2.2	60-0-0	24.0	60-0-60	25.9	1.9*
25	Richland sil	82	St.	12.3	19.6	3.3	80-0-0	16.4	80-0-60	17.9	1.5
26	Richland sil	94	Pl.	15.2	18.0	0.6	40-0-0	16.3	40-0-60	17.0	0.7*
27	Richland sil	69	St.	17.6	21.6	1.4	100-0-0	20.3	100-0-60	22.9	2.6*
28	Olivier sil	58	Pl.	25.0	26.6	0.8	40-40-0	25.7	40-40-60	27.6	1.9
28	Olivier sil	58	St.	19.0	21.4	1.5*	100-40-0	20.2	100-40-60	23.8	3.6*
28	Olivier sil	58	St.	22.0	24.3	2.9	80-40-0	25.0	100-40-80	28.8	3.8
Average for Terrace Soils			Pl.	23.1	26.3	0.7		26.0		27.6	1.6
Average for Terrace Soils			St.	19.7	23.6	2.2		24.9		27.3	2.4

*Significant at 5% level of probability.

Pl. = Plant cane; St. = Stubble cane.

Results from the factorial analysis

Yield responses to fertilizer potassium as determined by the factorial method were positive in all experiments on Alluvial soils. A maximum response to fertilizer potassium of 1.90 tons per acre with a yield increase of 9.2 per cent was obtained on Commerce loam at Smithfield Plantation with stubble cane. Average responses for all locations on Alluvial soils with plant and stubble cane were 0.7 and 0.9 tons per acre, respectively.

Positive responses to fertilizer potassium were obtained in all except two experiments on Older Alluvial or Terrace soils. A maximum response of 3.3 tons per acre with a yield increase of 16.7 per cent was obtained on Richland silt loam at Young's Industries, Inc. with stubble cane. Average responses for all locations on Older Alluvial or Terrace soils with plant and stubble cane were 0.7 and 2.2 tons per acre, respectively. Holmes (59) obtained similar results which indicated that the deficiency of potassium was greater in the Older Alluvial or Terrace soils along Bayou Teche than in the Alluvial soils along the Mississippi River and Bayou Lafouche. This is partially due to the fact that older soils are more weathered.

The relationship between available soil potassium extracted with 0.1 N HCl at 1:20 ratio and response of plant and stubble cane to fertilizer potassium as determined by the factorial method was evaluated. A regression equation with a non-significant coefficient was obtained for this relationship.

Results from the comparative analysis

Yield responses to fertilizer potassium as determined by the comparative method were positive in all experiments on Alluvial soils.

A maximum response of 3.3 tons per acre with a yield increase of 13.9 per cent was obtained on Moon loam at Smithfield Plantation with first stubble cane. Average responses for all locations on Alluvial soils with plant and stubble cane were 1.2 and 1.3 tons per acre, respectively.

Yield responses to fertilizer potassium were positive in all experiments on Older Alluvial or Terrace soils. A maximum response of 3.8 tons per acre with a yield increase of 15.2 per cent was obtained on Olivier silt loam at Young's Industries, Inc. in Lafayette Parish. Average responses for all locations on Older Alluvial or Terrace soils with plant and stubble cane were 1.6 and 2.4 tons per acre, respectively.

The relationship between available soil potassium extracted with 0.1 N HCl at 1:20 ratio and response of plant and stubble sugar cane to fertilizer potassium as determined by the comparative method is shown in Figure 5. A significant regression equation with a coefficient of .620 was obtained for this relationship. Greater responses were obtained on Older Alluvial or Terrace soils than on Alluvial soils. The regression curve shows that a profitable response of more than one ton per acre was obtained on soils which contained less than 120 ppm. of available potassium. This is in accordance with previous work in Louisiana. Sturgis and Byrnside (125) reported in a summary of ten years work that over 50 per cent of the soils tested in the sugar cane area was low in exchangeable potassium and that response to fertilizer potassium could be expected if the exchangeable potassium is below 110-160 ppm. (27). Holmes (57) in 1937 found a high negative correlation between soil potassium extracted with 0.05 N

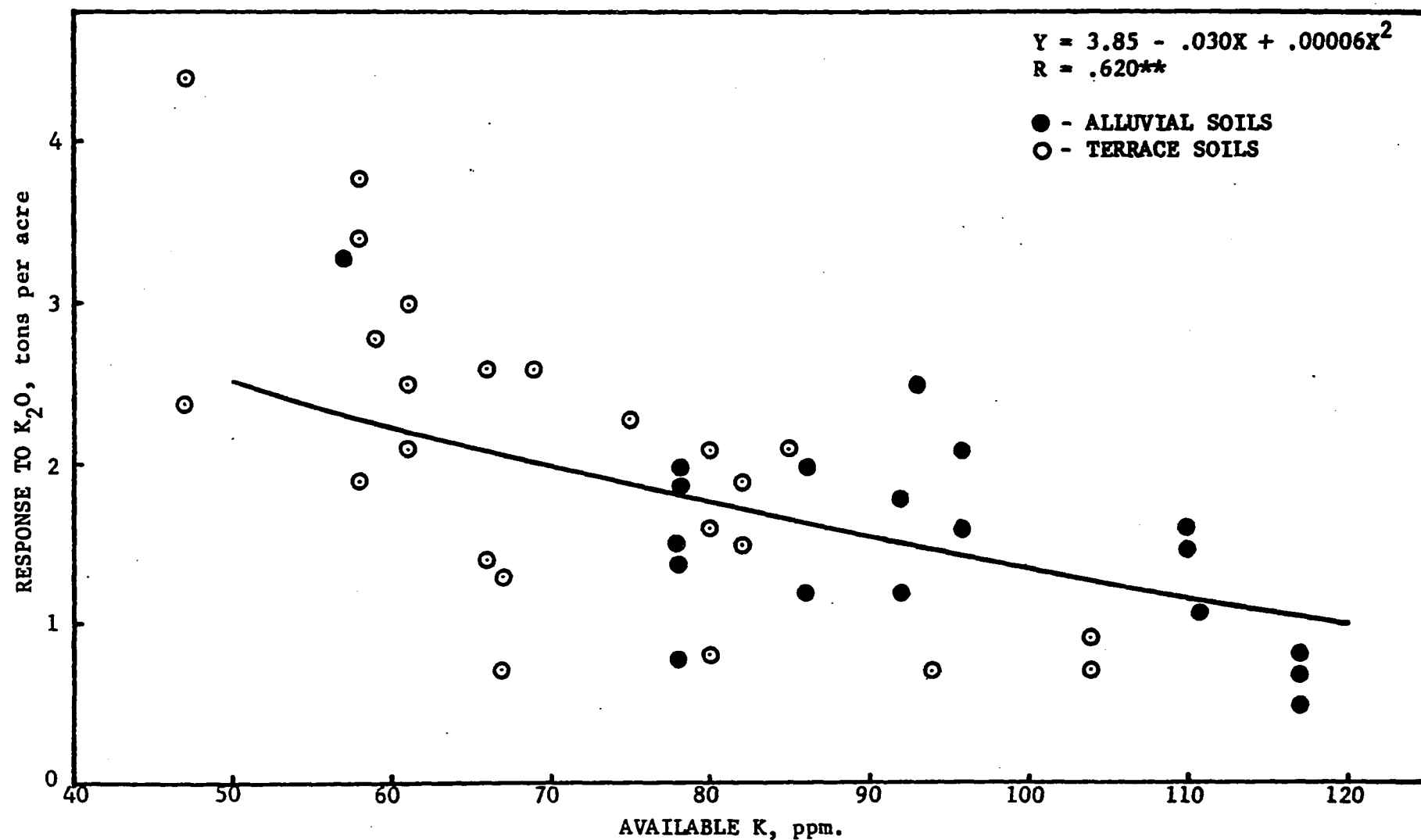


Figure 5. Relationship between response to K₂O and available K extracted with 0.1N HCL at 1:20 soil to solution ratio.

HCl at 1:10 ratio and response of sugar cane to fertilizer potassium. He obtained responses where the extractable potassium was less than 260 ppm. This responsive level of potassium is considerably higher than levels set in more recent studies. Humbert (61) in Hawaii found that the critical level of exchangeable soil potassium for sugar cane was 75 ppm. Ayres and Hagihara (9) obtained no yield increase due to fertilizer potassium where the soil contained more than 100 ppm. of potassium.

The current general recommendation for fertilizer potassium for sugar cane in Louisiana is 80 pounds of K_2O per acre. This recommendation is in close agreement with those in other sugar cane producing areas. According to Halliday (50) the present world-wide recommendation of fertilizer potassium for sugar cane at the medium level of available soil potassium of 100 to 120 ppm. is 82 pounds of K_2O per acre.

Deficiency symptoms observed on leaves of sugar cane on plots without applied fertilizer are shown in Figure 6. The leaves on the left side show a potassium deficiency and the ones on the right side show a nitrogen deficiency. The picture in Figure 7 also shows a potassium deficiency on leaves of sugar cane.

Uptake of Potassium by Sugar Cane

Data on the uptake of potassium by sugar cane are shown in Tables 15 through 18. These data were obtained at harvest time from six replicated fertilizer treatments in four of the experiments. An analysis of variance of the data obtained at each location was made as shown in Table 19.

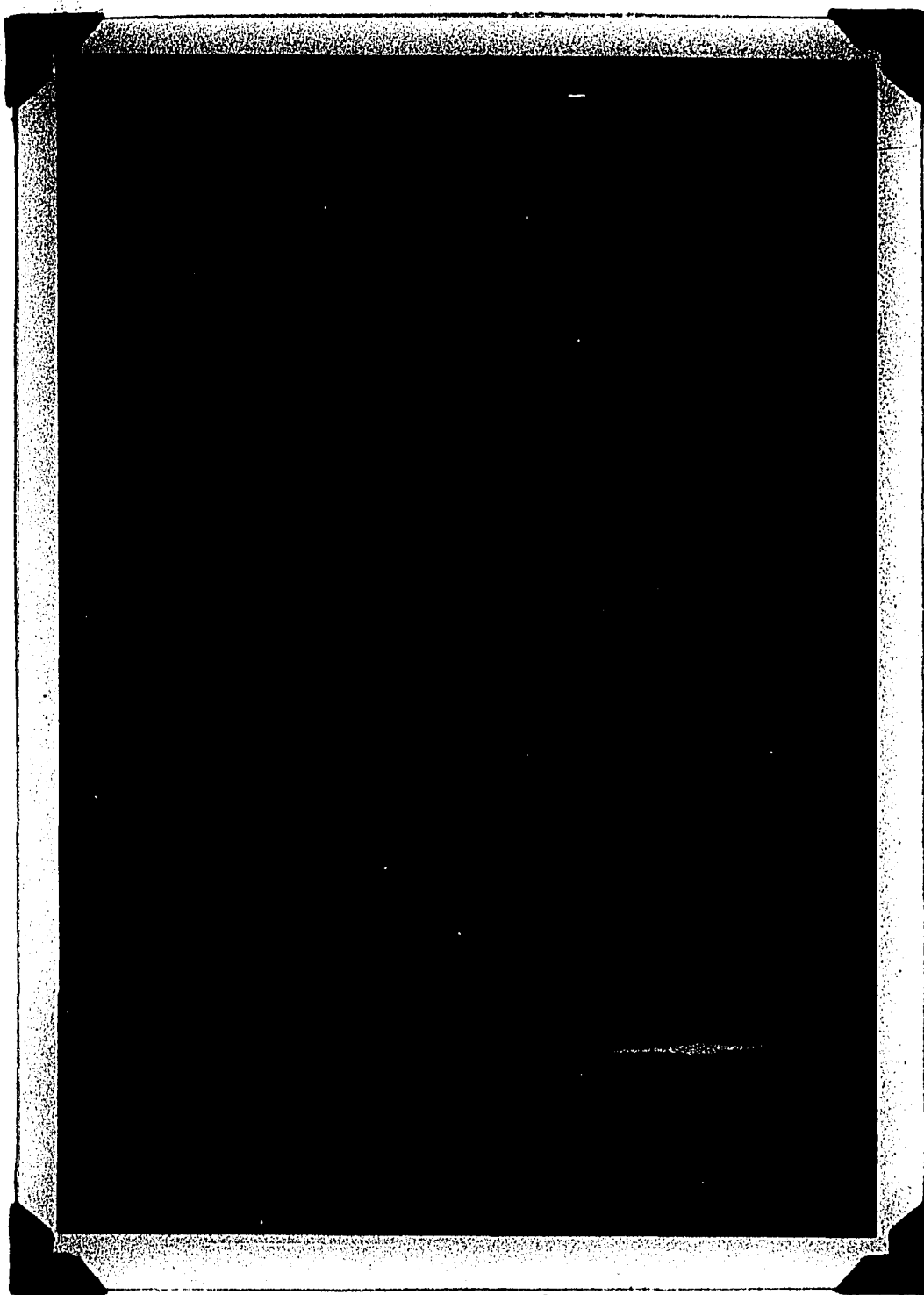


Figure 6. Deficiency symptoms in sugar cane. The three leaves to the left show a potassium deficiency and the two leaves to the right show a nitrogen deficiency.

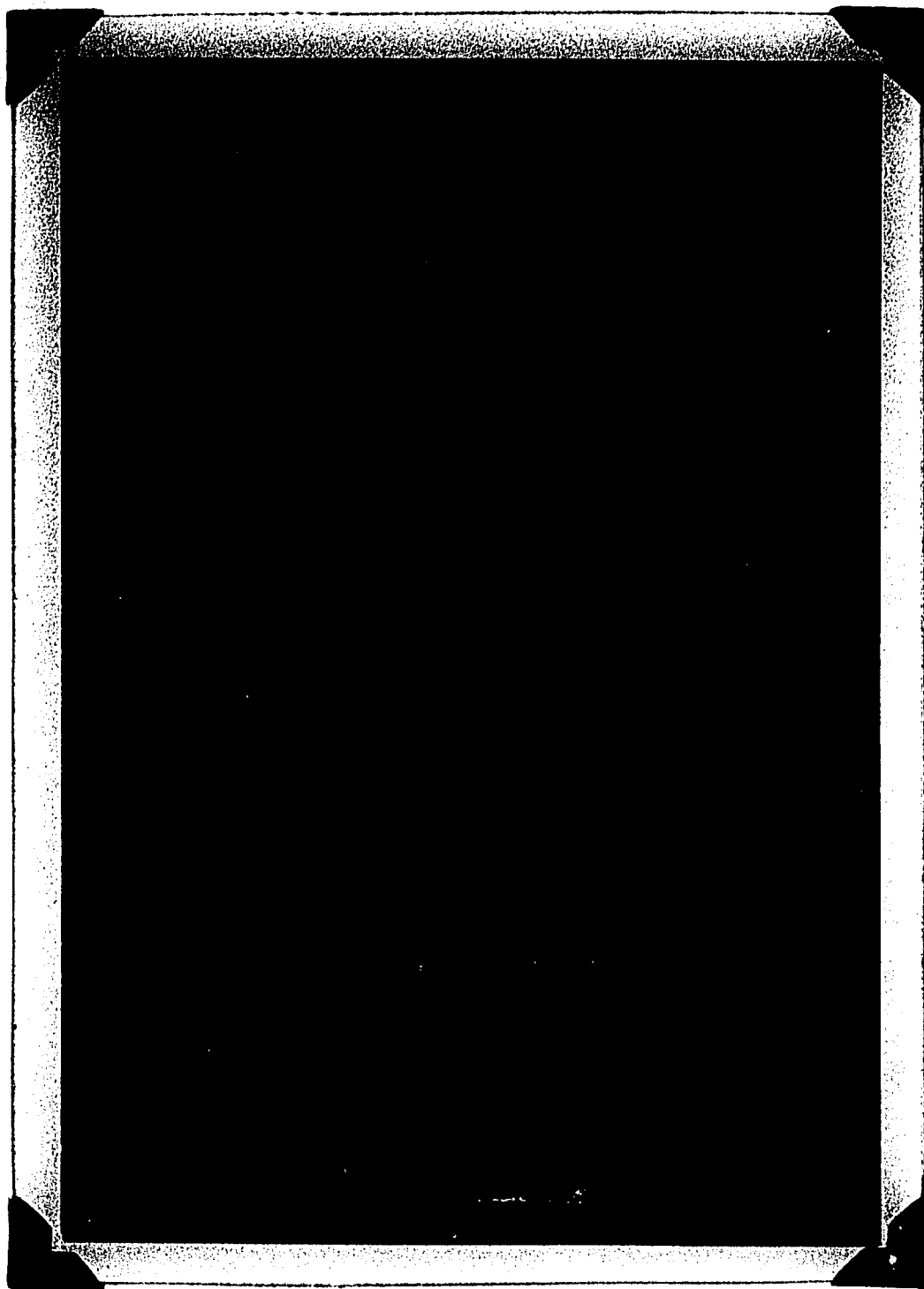


Figure 7. Potassium deficiency symptom in sugar cane.

Table 15. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, 1st stubble C. P. 52-68, on Moon silt loam¹ at Little Texas Plantation in 1961.

Fertilizer Treatment	Cane Yield	Sucrose	Sugar Yield	K ₂ O in Above-ground Plant Parts		
				Tops and Trash	Millable Cane	Total Growth
N-P ₂ O ₅ -K ₂ O Lbs./A.	T/A.	%	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
0-0-0	25.60	12.05	4849	99.7	79.1	178.8
80-0-0	31.98	11.97	6384	87.9	56.5	144.4
120-0-0	30.19	12.21	5993	88.3	58.7	147.0
120-40-0	33.88	12.09	6737	94.3	56.4	150.7
120-0-80	34.51	12.23	6671	102.1	83.2	185.3
120-40-80	34.33	12.46	6806	99.0	69.3	168.3
Average				95.2	67.2	162.4
Increase Due to K ₂ O ²	4.32**	0.02	678*	13.8	24.5**	38.3**

¹Available soil K extracted with 0.1 N HCl at 1:20 ratio was 78 ppm.

²Increase due to 80 Lbs./A. K₂O with N applications.

*Significant at 5%; **Significant at 1%.

Table 16. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, plant C. P. 52-68, on Commerce silt loam¹ at Alma Plantation in 1962.

Fertilizer Treatment	Cane Yield	Sucrose	Sugar Yield	K ₂ O in Above-ground Plant Parts		
				Tops and Trash	Millable Cane	Total Growth
N-P ₂ O ₅ -K ₂ O lbs./A.	T/A.	%	lbs./A.	lbs./A.	lbs./A.	lbs./A.
0-0-0	27.98	11.87	4853	80.5	87.8	168.3
80-0-0	29.59	11.37	5322	97.8	86.2	183.9
120-0-0	27.52	11.92	5170	89.7	66.0	155.7
120-40-0	27.08	11.92	4348	87.4	66.4	153.9
120-0-80	29.50	11.68	5122	101.3	90.0	191.3
120-40-80	30.05	11.78	5547	110.3	98.1	208.5
Average				94.5	82.4	176.9
Increase Due to K ₂ O ²	2.97	-0.14	1199*	22.9	31.7*	54.6**

¹Available soil K extracted with 0.1 N HCl at 1:20 ratio was 92 ppm.

²Increase due to 80 lbs./A. K₂O with N and P₂O₅ applications.

*Significant at 5%; **Significant at 1%.

Table 17. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, 1st stubble C. P. 52-68, on Cypremort silt loam¹ at Alice "B" Plantation in 1961.

Fertilizer Treatment	Cane Yield	Sucrose	Sugar Yield	K ₂ O in Above-ground Plant Parts		
				Tops and Trash	Millable Cane	Total Growth
N-P ₂ O ₅ -K ₂ O Lbs./A.	T/A.	%	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
0-0-0	27.88	14.02	6108	70.9	60.7	131.6
80-0-0	30.20	13.79	6556	76.4	62.3	138.7
120-0-0	31.52	13.86	6694	80.2	53.3	133.5
120-40-0	34.71	13.21	7311	75.1	62.3	137.4
120-0-80	34.18	13.21	7348	83.7	93.0	176.7
120-40-80	33.32	13.76	7077	77.2	75.2	152.4
Average				77.3	67.8	145.1
Increase Due to K ₂ O ²	2.66	-0.65	654	3.5	39.7**	43.2*

¹Available soil K extracted with 0.1 N HCl at 1:20 ratio was 47 ppm.

²Increase due to 80 Lbs./A. K₂O with N applications.

*Significant at 5%; **Significant at 1%.

Table 18. Effect of fertilizers on yield, per cent of sucrose and potassium uptake of sugar cane, plant N. Co. 310, on Baldwin silt loam¹ at Alice "B" Plantation in 1962.

Fertilizer Treatment	Cane Yield	Sucrose	Sugar Yield	K ₂ O in Above-ground Plant Parts		
				Tops and Trash	Millable Cane	Total Growth
N-P ₂ O ₅ -K ₂ O Lbs./A.	T/A.	%	Lbs./A.	Lbs./A.	Lbs./A.	Lbs./A.
0-0-0	35.81	15.77	8125	93.4	112.4	205.8
80-0-0	36.39	14.92	8297	83.8	73.8	157.6
120-0-0	38.33	14.17	8544	86.3	74.7	161.0
120-40-0	38.44	14.36	8341	91.0	91.1	182.1
120-0-80	36.99	14.25	8123	86.3	80.0	166.3
120-40-80	39.77	14.91	8936	97.6	107.0	204.6
Average				89.7	89.8	179.6
Increase Due to K ₂ O ²	1.33	0.55	595	6.6	15.9**	22.5*

¹Available soil K extracted with 0.1 N HCl at 1:20 ratio was 66 ppm.

²Increase due to 80 Lbs./A. K₂O with N and P₂O₅ applications.

*Significant at 5%; **Significant at 1%.

Table 19. Analysis of variance for Potassium uptake by millable sugar cane, 1st stubble C. P. 52-68, on Moon silt loam at Little Texas Plantation in 1961.

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	F Value
Replication	2	215.59	107.80	1.49
P	1	199.27	199.27	2.76
K	1	1065.97	1065.97	14.75**
P x K	1	98.03	98.03	1.36
Error	6	433.49	72.25	
Total	11	2012.35		

**Significant at 1% level.

Data on potassium uptake obtained on Mhoon silt loam at the Little Texas Plantation in 1961 are shown in Table 15. The average potassium uptake contained in the tops, millable cane and total above-ground growth was 95.2, 67.2 and 162.4 pounds of K_2O per acre, respectively. Only 41.4 per cent of the total uptake was contained in the millable cane and actually removed from the field. The potassium contained in the millable cane varied from 1.66 to 3.09 pounds of K_2O per ton with an average of 2.15 pounds of K_2O per ton of millable cane. Golden (45, 46) studied the potassium uptake on five soil types and reported a range in uptake from 2.44 to 4.15 pounds of K_2O per ton of millable cane. Potassium uptake contained in the total above-ground growth varied from 4.45 to 6.98 with an average of 5.18 pounds of K_2O per ton of millable cane. The application of fertilizer nitrogen lowered the potassium uptake, but the uptake was increased with the nitrogen plus potassium fertilizer treatments. Significant increases in potassium uptake due to the addition of 80 pounds of K_2O were 24.5 pounds of K_2O per acre in the millable cane and 38.3 pounds of K_2O per acre in the total above-ground growth. Increase in sucrose content due to addition of potassium was not significant. Samuels (112) in Puerto Rico found that fertilizer potassium applications increased the sucrose content of sugar cane only when significant increases in cane tonnage due to potassium applications were obtained.

Data on potassium uptake obtained on Commerce silt loam at Alma Plantation in 1962 are shown in Table 16. Average potassium uptake contained in the tops, millable cane and total above-ground growth was 94.5, 82.4 and 176.9 pounds of K_2O per acre, respectively. Only 46.6 per cent of the total uptake was contained in the millable cane.

Average potassium uptake per ton of millable cane was 2.87 pounds of K_2O in the millable cane and 6.17 pounds of K_2O in the total above-ground growth. Significant increases in potassium uptake due to the addition of 80 pounds of K_2O were 31.7 pounds of K_2O per acre in the millable cane and 54.6 pounds of K_2O per acre in the total above-ground growth.

Data on potassium uptake obtained on Cypremort silt loam at Alice "B" Plantation in 1961 are shown in Table 17. Average potassium uptake contained in the tops, millable cane and total above-ground growth was 77.3, 67.8 and 145.1 pounds of K_2O per acre, respectively. The millable cane contained 46.7 per cent of the potassium in the total above-ground growth. Average potassium uptake per ton of millable cane was 2.12 pounds of K_2O in the millable cane and 4.54 pounds of K_2O in the total above-ground growth. Average increases in potassium uptake due to the addition of 80 pounds of K_2O were 39.7 pounds of K_2O per acre in the millable cane and 43.2 pounds of K_2O per acre in the total above-ground growth.

Data on potassium uptake obtained on Baldwin silt loam at Alice "B" Plantation in 1962 are shown in Table 18. Average potassium uptake contained in the tops, millable cane and total above-ground growth was 89.7, 89.8 and 179.6 pounds of K_2O per acre, respectively. One half or 50.0 per cent of the total uptake was contained in the millable cane and actually removed from the field. Potassium uptake contained in the millable cane varied from 1.95 to 3.14 with an average of 2.39 pounds of K_2O per ton of millable cane. Potassium uptake contained in the total above-ground growth varied from 4.20 to 5.75 with an average of 5.18 pounds of K_2O per ton of millable cane. The application of fertilizer nitrogen alone lowered the potassium uptake, but the uptake

was partially restored with complete fertilizer. Significant increases in potassium uptake due to the addition of 80 pounds of K_2O were 15.9 pounds of K_2O per acre in the millable cane and 22.5 pounds of K_2O per acre in the total above-ground growth. These values are much lower than for the other locations. An increase in sucrose of 0.55 per cent due to fertilizer potassium was not significant. Naquin (88) found that sugar cane receiving fertilizer potassium and nitrogen gave better quality juice than sugar cane receiving fertilizer nitrogen alone.

The data obtained at the four locations were analyzed by an analysis of variance method for combined experiments. The F values obtained are shown in Table 20. Significant differences were obtained among the four locations. Significant differences in the potassium content of millable cane and total above-ground growth were obtained due to additions of fertilizer potassium. Burr and Tonimoto (25) found that well-fed sugar cane plants contained three times as much potassium as potassium starved plants. It was found from the analysis of the four locations that fertilizer potassium significantly increased the sugar yield but not the cane yield (Table 20).

Rainfall and Yield of Sugar Cane

Precipitation in inches of rainfall measured at each experimental location is shown in Table 21. The rainfall varied widely among months of the year, among years and among experimental locations.

Simple correlation coefficients were calculated between rainfall during different periods of the year and yield of sugar cane from three different fertilizer treatments. Correlations were also obtained between rainfall and response of sugar cane to fertilizer potassium.

Table 20. F values for each source of variation in yield, per cent of sucrose and potassium uptake of sugar cane calculated in analyses of variance for combined experiments for the four experimental locations.

Source of Variation	Degree of Freedom	F Value					
		Cane Yield	Per Cent Sucrose	Sugar Yield	K ₂ O Content of Above-ground Plant Parts		
					Tops and Trash	Millable Cane	Total Growth
Replication	2	2.15	0.03	1.58	0.86	8.85**	0.66
Location	3	32.50**	162.57**	115.37**	4.13	13.19**	7.37*
P	1	2.46	0.63	1.86	0.18	1.62	1.07
K	1	3.78	0.00	5.55*	4.00	63.21**	34.24**
Loc. x P	3	0.28	0.61	1.08	0.49	6.37*	3.32
Loc. x K	3	0.78	0.61	0.63	0.68	2.29	1.64
P x K	1	0.57	2.97	0.53	0.05	0.89	0.10
Loc. x P x K	3	1.47	0.73	4.29	0.30	2.76	1.55

*Significant at 5% level; **Significant at 1% level.

Table 21. Precipitation in inches of rainfall at experimental locations.

Month	Experimental Location Number											
	1 1959	2 1954	1956	3 1959	1960	4 1962	1963	1954	5 1955	1956	6 1958	1959
January	5.1	6.2	3.5	5.3	6.4	7.7	8.1	6.2	5.8	3.7	5.8	4.1
February	7.1	1.9	11.1	10.1	3.9	1.7	3.3	1.3	4.9	7.4	3.5	10.3
March	2.8	2.2	2.6	2.0	2.1	4.5	0.3	1.2	0.0	3.6	7.0	2.8
April	3.1	3.4	3.2	3.9	3.3	14.6	3.3	4.5	8.3	4.0	2.9	1.7
May	5.8	7.5	3.1	7.9	4.2	11.8	1.6	8.2	6.3	8.0	5.7	12.9
June	5.1	2.6	2.9	5.6	1.7	3.0	2.9	6.2	2.5	6.5	2.2	4.4
July	6.2	8.2	6.5	15.3	3.7	1.2	11.3	14.1	11.3	5.4	7.8	13.3
August	6.5	3.9	4.3	7.3	7.7	6.6	1.3	3.0	9.3	2.8	5.2	8.4
September	1.0	7.4	1.5	6.0	1.7	7.4	2.8	3.8	3.6	7.5	8.6	2.6
October	4.2	6.2	6.6	4.3	1.7	7.4	0.0	3.7	2.1	1.5	0.9	5.7
November	2.5	1.9	1.4	4.2	1.7	1.3	0.4	2.6	3.0	3.3	1.4	0.9
December	7.1	5.7	4.1	6.2	5.2	4.6	6.2	5.0	3.9	8.1	1.7	4.4
Year Total	56.3	56.9	44.8	78.0	43.3	71.8	41.3	59.7	61.0	61.7	52.7	71.4
April-Sept.	27.6	32.9	21.5	46.0	22.3	44.6	23.1	39.8	41.3	34.1	32.3	43.3
Prior Yr. Total	54.9	86.0	55.0	59.7	78.0	82.0	71.8	73.3	59.7	61.0	75.2	52.7

Table 21. Continued.

Month	Experimental Location Number										
	7 1963	8 1958	1960	9 1961	1962	10 1960	1961	11 1963	12 1962	1963	13 1961
January	3.1	5.4	3.3	5.7	5.7	4.1	6.2	3.0	3.8	3.5	2.1
February	5.4	3.7	4.0	10.6	1.2	5.1	10.0	5.8	1.7	5.6	5.1
March	1.1	7.1	2.7	7.1	2.2	5.8	12.8	0.6	1.8	1.1	2.1
April	2.0	4.5	5.7	2.2	2.7	3.2	3.6	1.4	2.4	1.9	0.5
May	3.3	2.9	4.1	4.6	1.1	1.5	5.3	2.7	1.9	2.2	4.0
June	9.1	9.6	3.7	10.7	7.5	0.7	8.5	7.9	6.9	9.4	14.0
July	7.9	9.7	5.6	7.5	1.9	6.7	8.4	4.0	3.2	9.3	5.3
August	4.5	6.0	8.1	10.7	3.0	10.2	7.5	4.1	4.1	3.0	2.1
September	5.3	5.6	0.9	10.0	2.5	3.4	7.5	4.4	1.4	6.4	1.5
October	0.1	1.7	3.0	0.9	2.2	7.7	0.8	0.0	2.2	0.0	0.8
November	10.9	1.4	1.7	8.3	1.4	0.1	5.8	8.4	1.6	12.7	7.5
December	4.8	2.4	3.9	7.8	4.9	3.7	5.8	4.1	2.3	4.4	6.1
Year Total	57.3	59.7	46.7	86.0	36.3	52.2	82.0	46.6	33.1	59.7	51.1
April-Sept.	32.1	38.1	28.1	45.6	18.7	25.7	40.7	24.6	19.9	32.4	27.4
Prior Yr. Total	39.6	61.7	71.4	46.7	86.0	76.8	52.2	30.0	82.0	82.0	45.6

Table 21. Continued.

Month	Experimental Location Number											
	14			15		16			17		18	19
	1956	1957	1958	1962	1963	1958	1959	1960	1959	1960	1963	1961
January	1.5	0.0	5.0	3.1	5.8	4.4	3.3	0.7	3.9	0.0	3.4	4.7
February	4.4	1.4	3.5	0.2	3.1	4.6	9.1	4.8	10.2	3.4	2.7	2.7
March	0.5	5.7	3.5	1.3	0.1	5.3	2.2	4.4	2.6	4.5	0.8	3.6
April	2.5	3.5	3.0	1.6	0.6	3.3	3.6	5.6	1.2	3.8	0.7	1.9
May	5.4	0.6	4.0	1.6	2.8	6.9	10.8	2.1	9.9	2.4	1.6	7.7
June	1.2	12.4	1.5	6.8	11.4	5.6	2.6	4.6	3.3	1.0	6.1	6.8
July	6.4	4.8	6.4	2.5	5.9	10.7	10.5	6.5	8.7	6.8	5.1	10.1
August	2.5	1.7	5.9	1.8	4.0	8.9	9.5	13.3	4.1	10.1	4.6	6.5
September	1.0	5.1	3.4	2.8	16.3	7.0	2.6	1.5	4.7	4.0	3.7	4.1
October	0.1	7.8	0.8	1.0	1.5	1.2	9.0	3.9	9.9	5.2	0.0	1.8
November	1.8	3.6	1.9	1.3	7.1	0.8	0.6	1.3	0.1	0.5	4.9	4.4
December	5.4	2.1	1.2	1.5	5.1	1.5	3.8	5.7	3.8	4.0	2.7	9.0
Year Total	32.8	48.6	40.1	25.3	63.7	59.3	67.4	54.1	62.2	45.6	36.1	63.2
April-Sept.	19.1	28.2	24.2	17.0	41.0	41.7	39.5	33.5	31.8	28.0	21.6	37.1
Prior Yr. Total	51.1	32.8	48.6	51.1	25.3	70.4	59.3	67.4	40.1	62.2	42.3	45.6

Table 21. Continued.

Month	Experimental Location Number											
	20		21		22	25		26	27	28		
	1962	1963	1955	1956	1956	1954	1955	1956	1957	1959	1960	1961
January	4.1	6.6	5.9	3.3	3.4	5.2	4.8	2.3	1.4	4.1	2.4	4.7
February	1.1	2.6	3.7	6.6	11.8	0.9	7.2	9.2	5.3	11.5	2.9	4.7
March	1.5	1.3	0.0	2.8	2.4	1.8	0.0	3.5	9.0	2.3	1.7	2.5
April	1.8	0.5	6.4	2.2	1.9	2.5	6.4	1.8	6.9	2.8	2.3	2.6
May	0.7	0.2	5.3	1.0	5.7	1.4	13.0	3.5	4.6	6.7	2.3	8.3
June	8.6	11.0	6.8	2.2	6.2	1.5	6.5	6.6	8.8	5.2	2.8	10.1
July	3.8	7.7	14.2	4.7	6.9	12.8	4.9	5.1	3.9	7.9	7.9	5.0
August	3.5	4.1	14.7	8.9	7.1	2.1	8.0	6.1	4.2	2.6	6.4	9.5
September	5.9	8.1	4.1	5.4	3.5	1.1	1.7	3.1	8.7	1.4	0.7	1.0
October	1.9	0.0	1.1	3.6	1.1	6.6	0.6	1.6	5.6	8.5	2.7	0.8
November	0.8	6.8	3.2	4.5	0.0	1.6	3.0	5.6	4.8	2.5	0.8	7.2
December	6.2	4.1	3.9	6.6	7.0	3.1	5.8	8.0	3.8	3.9	5.7	5.5
Year Total	39.8	52.9	69.1	60.5	57.0	40.5	61.8	56.3	67.1	59.3	38.5	66.8
April-Sept.	24.2	31.6	51.4	33.3	31.3	21.4	40.4	26.2	37.1	26.5	22.4	41.5
Prior Yr. Total	63.2	39.8	56.9	69.1	61.3	58.1	40.5	61.8	60.1	54.8	59.3	38.5

The fertilizer treatments used were no fertilizer, nitrogen only and complete fertilizer. The periods of rainfall used in the correlations were rainfall during each month, rainfall during March, April and May, rainfall during June, July and August, rainfall from April through September, total rainfall for the year and total rainfall for the previous year. In addition to obtaining the correlations for all the experiments as a group, they were obtained for experiments from 1954 through 1960 and for experiments after 1960. The correlations were also calculated for experiments on the Alluvial soils and for experiments on the Older Alluvial or Terrace soils for the entire period 1954-1963. Finally, the correlation values were obtained for experiments with plant cane and for experiments with stubble cane for the entire period.

Table 22 contains only the correlation values which appear to be important. Although several of the correlations are statistically significant, only a few are considered highly important. A majority of the correlation values shows a negative association between yield of sugar cane and rainfall. Generally, this association was more pronounced on Older Alluvial or Terrace soils than on Alluvial soils and more pronounced with stubble than with plant cane.

Lal (74) studied the relationship between rainfall and yield of sugar cane in Louisiana during a period of several years. He concluded that an association occurred between an early dry spring and higher yields of sugar cane. This conclusion is in general agreement with the results obtained in this study. It is apparent that excessive rainfall during the spring of the year could cause a reduction in yield. The exact reason for this association is not well known. It is very

Table 22. Simple correlation coefficients showing the relationship between rainfall during different periods and sugar cane yield in fertilizer experiments.

Number of Experiments, Soil Group, Age of Cane, Year of Experiment	Period of Rainfall	r-value			
		Yield without Fert.	Yield with N	Yield with NPK	nse co K
47 Experiments, Alluvial and Terrace, Plant and Stubble, 1954 to 1963	August	-.304*	-.286	-.225	--
	November	.334*	.362*	.429**	--
	Mar.-May	-.279	-.270	-.223	.130
	June-Aug.	-.134	--	--	--
	Apr.-Sept.	-.324*	-.265	-.216	--
	Prior Year	-.282	-.338*	-.434**	-.229
30 Experiments, Alluvial and Terrace, Plant and Stubble, 1954 to 1960	January	.118	.180	.253	-.409*
	July	.114	.113	.117	-.383*
	October	.274	.379*	.336	.134
	November	-.203	-.269	-.423*	--
	Year Total	-.126	-.101	--	-.380*
17 Experiments, Alluvial and Terrace, Plant and Stubble, 1961 to 1963	November	.227	.428	.554*	.168
	December	-.367	-.328	-.234	.650**
	June-Aug.	-.141	--	.210	.504*
	Prior Year	-.441	-.565*	-.670**	-.159

Table 22. Continued.

Number of Experiments, Soil Group, Age of Cane, Year of Experiment	Period of Rainfall	r-Value			
		Yield without Fert.	Yield with N	Yield with NPK	Response to K
22 Experiments, Alluvial Soils Only, Plant and Stubble, 1954 to 1963	November	.509*	.502*	.608**	--
	Prior Year	-.242	-.274	-.432*	-.150
25 Experiments, Terrace Soils Only, Plant and Stubble, 1954 to 1963	March	-.342	-.462*	-.480*	.267
	April	-.629**	-.583**	-.552**	.294
	August	-.549**	-.527**	-.470*	.120
	Mar.-May	-.498*	-.462*	-.346	.373
	Apr.-Sept.	-.427*	-.289	-.192	.150
	Year Total	-.438*	-.299	-.210	.198
	Prior Year	-.458*	-.599**	-.645**	--
18 Experiments, Alluvial and Terrace, Plant Cane Only, 1954 to 1963	June	--	-.264	-.279	-.530*
	June-Aug.	-.476*	-.380	-.439	-.161
29 Experiments, Alluvial and Terrace Stubble Cane Only, 1954 to 1963	April	-.452*	-.408*	-.388*	--
	June	.402*	.328	.370*	--
	September	.260	.342	.397*	-.371*
	October	-.372*	-.244	-.358	.192
	November	.642**	.560**	.631**	-.120
	Mar.-May	-.438*	-.445*	-.288	--
	Prior Year	-.386*	-.426*	-.476**	-.312

*Significant at 5%; **Significant at 1% level.

probably that better cultivation, weed control and fertilization practices and better soil aeration are responsible for greater yields during a year with a relatively dry spring season.

General Discussion

Although this study presents information on the chemical and physical properties of the soil, the potassium uptake and rainfall as related to yield of sugar cane in Louisiana it has several limitations which should be discussed. Soils within the Alluvial group and within the Older Alluvial or Terrace group vary widely in their properties. It would have been better to study the individual soil types within each group as well as by groups. This is particularly true for the Old Alluvial or Terrace soils. The Richland and Olivier soils are older, shallower, and more depleted of nutrient elements than the Cypremort, Baldwin, Jeanerette and Iberia soils. There is also considerable variation within a soil series, i. e. available potassium in Baldwin soils.

The depth of the feeding zone in the soil should be considered in the determination of available nutrients by chemical methods. Shallow soils usually respond to applied potassium at higher soil test values than relatively deep soils such as the Yahola soils at lower test values. Also, since a portion of the plant roots feeds in the subsoil, the contribution of the subsoil to the growth of plants should be considered. Humbert (62) pointed out that the volume weight of a soil should be considered when critical levels of soil nutrients are established.

Although the amount of potassium removed by a crop is small relative to the total amount in the soil, a minimum level of available potassium should be maintained to produce normal plant growth. On the other hand, the maintenance of a very high level of available potassium in the soil is not only a needless expense but as Clements (29) pointed out, it can cause difficulty in the crystallization of sugar.

The amount and distribution of precipitation have a well-known influence on the yield of crops. This influence is partially due to effect of the soil moisture on the availability of soil and fertilizer nutrient elements to plants. It is probable that during dry seasons the availability of soil nutrients decreases and the yield response to applied fertilizer increases. Worsham (140) found that increasing soil moisture to saturation increased the available potassium.

It is apparent from this study that the response of sugar cane to fertilizer potassium varied widely and was not very highly associated with the total soil potassium. This was due in part to several factors such as the nature of the soil, depth of the soil, requirements of the crop, precipitation and other factors. It was also due in part to the conditions under which the experiments were conducted. These experiments were conducted on privately-owned plantations which naturally necessitated that the experiments conformed to plantation practices. These practices were not always highly conducive to good experimentation. In order to have more precise measurement of yield and calibration of soil testing methods with yield, it will be necessary in the future to conduct fertilizer experiments with sugar cane under better controlled conditions.

The response to fertilizer potassium was positive in most experiments conducted and in several cases statistically significant. The available potassium content of several soil series and some soil types within other series was at a responsive level below 120 ppm. As the yield of sugar cane increases, the potassium content of more soils will be at a responsive level and consequently the usage of fertilizer potassium will increase. It is conceivable that within the next ten years, most of the sugar cane farmers will be applying recommended rates of fertilizer potassium.

SUMMARY AND CONCLUSIONS

A study was made of the total soil potassium, exchangeable cations, other soil properties, the uptake of potassium and rainfall as related to yield and response of sugar cane to fertilizer potassium. Forty-nine fertilizer experiments were conducted at 28 locations on 16 soil types of the Alluvial soils and Older Alluvial or Terrace soils from 1954 to 1963.

A normal ammonium acetate solution extracted more potassium from the soils than a 0.1 N hydrochloric acid solution. This was particularly true for soils relatively high in clay content. More soil cations were extracted at a 1:20 than at a 1:10 soil to solution ratio with either extractant. Potassium extracted by the methods studied was generally higher in the Alluvial soils than in the Older Alluvial or Terrace soils. Although the available or 0.1 N hydrochloric acid extractable potassium was slightly lower in amount, it was highly associated with the exchangeable potassium. Available potassium was not highly associated with total soil potassium, but it was highly correlated with clay content and to a lesser degree with organic matter content of the soil. The per cent of organic matter for each per cent clay was on an average .085 in the Alluvial soils and .098 in the Older Alluvial or Terrace soils.

Results from a factorial analysis of the yield data of sugar cane revealed that a maximum yield response obtained to fertilizer potassium

was 1.9 tons per acre on Alluvial soils and 3.3 tons per acre on Older Alluvial or Terrace soils. In 4 of the experiments on the Alluvial soils, the response to fertilizer potassium was significant. The response to fertilizer potassium was significant in 10 of the experiments on the Older Alluvial or Terrace soils.

Results from a comparative analysis of the yield data of sugar cane revealed that the maximum yield response obtained to fertilizer potassium was 3.3 tons per acre on the Alluvial soils and 3.8 tons per acre on the Older Alluvial or Terrace soils. The relationship between available soil potassium and response of sugar cane to fertilizer potassium as determined by the comparative method of analysis was significant. The regression equation for this relationship shows that a profitable response of more than one ton per acre was obtained on soils which contained less than 120 ppm. of available potassium. Greater responses were obtained with stubble cane than with plant cane.

As an average of the 4 locations studied, the potassium uptake per ton of millable sugar cane was 2.38 pounds as K_2O in the millable cane and 5.27 pounds as K_2O in the total above-ground growth. The millable cane contained 45.2 per cent of the potassium in the total above-ground growth.

Simple correlation coefficients between rainfall during different periods of the year and yield of sugar cane revealed that in many cases studied a lower rainfall was associated with an increase in yield. This effect was more pronounced on Older Alluvial or Terrace soils than on Alluvial soils and more pronounced with stubble than with plant sugar cane.

BIBLIOGRAPHY

1. Aguirre, J. M., Arruda, H. C., and Rodriquez, A. J. A preliminary note on the field experimentation of the cane sugar section. Proc. 6th Congr. Int. Soc. Sug. Cane Tech. 672-679. 1938.
2. Alexander, W. P. Potash fertilization on Ewa Plantation. Hawn. Planters' Record. 30:438. 1926.
3. Anthony, W. H. Seasonal changes and error involved in sampling and laboratory procedure in the evaluation of soil fertility. Thesis, Louisiana State Univ. Library. 1949.
4. Attoe, O. J., and Truog, E. Exchangeable and acid-soluble potassium as regards availability and reciprocal relationships. Soil Sci. Soc. Am. Proc. 10:81. 1946.
5. Aughtry, J. D., and Lunin, J. The fertilization of certain irrigated soil types of the Dominican Republic. Proc. 8th Congr. Int. Soc., Sug. Cane Tech. 60-68. 1953.
6. Ayres, A. S. Variation of mineral content of sugar cane with age and season. Hawn. Planters' Record. 37:197-206. 1933.
7. _____. Effect of age upon the absorption of mineral nutrients by sugar cane under field conditions. J. Am. Soc. Agron. 28:871-886. 1936.
8. _____. Release of non-exchangeable potassium in Hawaiian sugar cane soils. Hawn. Agr. Exp. Sta. Tech. Bull. 9:1-50. 1949.
9. _____, and Hagihara, H. H. Soil analyses as index of nutrient availability. Hawn. Planters' Record. 55(1):117. 1955.
10. Barber, S. A., and Humbert, R. P. Fertilizer Technology and Usage. Braun-Brumfield, Inc., Ann Arbor, Michigan, 1963.
11. Baver, L. D. Soil Physics. John Wiley and Sons, Inc., New York. 1940.
12. _____. Plant and soil composition relationship as applied to cane fertilization. Hawn. Planters' Record. 56(1):31. 1960.
13. _____. Scientific feeding of high value crops. Plant Food Review. 6(3):8-11. Fall, 1960.

14. Bear, Firman E. Chemistry of the Soil. Reinhold Pub. Corp., N. Y. 1955.
15. Bonnet, J. A. Potassium content of Puerto Rican soils as related to sugar cane. Proc. 8th Congr. Int. Soc. Sug. Cane Tech. 132-139. 1953.
16. Borden, R. J. Effect of sunlight on utilization of nitrogen and potash by cane. Int. Sug. J. 40:33-34. 1938.
17. _____. Potash requirement for sugar cane. Hawn. Planters' Record. 45:131-146. 1941.
18. _____. The early development and rate of uptake by sugar cane. Hawn. Planters' Record. 48:43-53. 1944.
19. Bray, R. H. Calibrating soil tests for available potassium. Soil Sci. Soc. Am. Proc. 1:225-231. 1937.
20. _____, and DeTurk, E. E. The release of potassium from non-replaceable forms in Illinois soils. Soil Sci. Soc. Am. Proc. 3:101. 1939.
21. Bregger, T., and Bedsole, M. R. Physiology of sugar cane. Report Florida Agr. Exp. Sta. 232. 1953.
22. Browne, C. A. Soils and Men. U. S. Dept. of Agr. Yearbook. U. S. Government Printing Office, Wash., D. C. 1938.
23. _____, and Blouin, R. E. The chemistry of the sugar cane and its products in Louisiana. Louisiana Agr. Exp. Sta. Bull. 91. 1907.
24. Burr, G. O. Plant analyses as indexes of nutrient availability and adequacy. Hawn. Planters' Record. 55:106. 1955.
25. _____, and Tonimoto, T. Absorption and distribution of nutrients in sugar cane. II. Potassium. Hawn. Planters' Record. 55:11-16. 1955.
26. Byrnside, D. S., Jr., and Sturgis, M. B. Soil phosphorus and its fractions as related to response of sugar cane to fertilizer phosphorus. Louisiana Exp. Sta. Bull. 513. 1958.
27. _____, and _____. Available potassium and the response of sugar cane to fertilizer potassium in the sugar cane area of Louisiana. Unpublished data. 1958.
28. Carey, T. M., and Robinson, P. The manuring of sugar cane. Emp. J. Exp. Agr. 21:99-115. 1953.
29. Clements, H. F. Sugar Cane Nutrition and Culture. Indian Institute of Sug. Cane Res. 1959.

30. Davidson, L. G. Comparative effects of selected fertilizer treatments on yields of different varieties of sugar cane. Proc. 8th Congr. Int. Soc. Sug. Cane Tech. 189-195. 1953.
31. _____, and Hurst, L. A. Soil fertility investigations on sugar cane in Louisiana. Sug. Bull. 21(3):20-22. 1942.
32. DeMent, J. D., and Sturgis, M. B. Fertilizer practices and their effect on the production of sugar cane. Sug. Bull. 30(13):229. 1952.
33. DeTurk, E. E., Wood, L. K., and Bray, R. H. Potash fixation in corn belt soils. Soil Sci. 55:1. 1943.
34. Drake, M., and Scarseth, G. D. Relative abilities of different plants to absorb potassium and the effects of different levels of potassium on the absorption of calcium and magnesium. Soil Sci. Soc. Am. Proc. 4:201. 1939.
35. Driskell, B. N. Chemical characteristic of certain profiles of alluvial soils in the lower Mississippi flood plain. Soil Sci. Soc. Am. Proc. 18:140. 1954.
36. _____. Methods and procedures for soil and plant analyses. Mimeograph Report, Dept. of Agron., Louisiana State Univ. 1954.
37. duToit, J. L. Potash: A neglected fertilizer. So. Afr. Sug. J. 35:377-387. 1951.
38. _____. Recent advances in nutrition of sugar cane in South Africa. Proc. 10th Congr. Int. Soc. Sug. Cane Tech. 432-441. 1959.
39. Evans, C. E., and Simon, R. H. Nonexchangeable potassium removal from soils by successive acid extractions as related to removal by greenhouse crops. Soil Sci. Soc. Am. Proc. 14:126. 1950.
40. Fraps, G. S., and Fudge, J. F. The availability of potash of the soil as measured by potassium experiments with corn. Soil Sci. Soc. Am. Proc. 4:205-208. 1939.
41. Fried, M., and Dean, L. A. A concept concerning the measurement of available soil nutrients. Soil Sci. 73:263-271. 1952.
42. Geerlings, H. C. P. The correlation between the sugar and potash contents of cane juice. Int. Sug. J. 13:417-421. 1911.
43. Gholston, L. E., and Hoover, D. C. The release of exchangeable and nonexchangeable potassium from several Mississippi and Alabama soils upon continuous croppings. Soil Sci. Soc. Am. Proc. 13:116. 1949.

44. Golden, L. E. Nutrient availability and uptake for sugar cane. Report of Projects, Dept. of Agron., Louisiana State Univ. 1959.
45. _____. Plant nutrients uptake by sugar cane in Louisiana. Sug. J. 22(11):21-22. 1960.
46. _____. Nutrient uptake by sugar cane in Louisiana. Sug. J. 23(11):22. 1961.
47. Gorbunov, N. I. The nature of potassium fixation in unexchangeable form. Abstr: Chem. Abstr. 30:6874. 1936.
48. Gouaux, C. G. Sugar cane test fields and fertilizer demonstrations. Louisiana Agr. Exp. Sta. Bull. 203. 1929.
49. Gruneberg, F. Potash manuring, an essential factor in agricultural production. World Crops. 320-324. Sept., 1958.
50. Halliday, D. J. The Manuring of Sugar Cane. The Netherhall Press and Shenval Press, Great Britain. 1956.
51. Hammond, L. C., Allaway, W. H., and Loomis, W. E. Effects of oxygen and carbon dioxide levels upon absorption of potassium by plants. Plant Physiol. 30(2):155-161. 1955.
52. Hartt, C. E. Potassium deficiency in sugar cane. Bot. Gaz. 88:229-261. 1929.
53. _____. Some effects of potassium upon the amounts of protein and amino forms of nitrogen, sugars, and enzyme activity of sugar cane. Plant Physiol. 9:453-490. 1934.
54. Hendrix, J. A. The course of the availability of the primary nutrients through a sugar cane rotation on Sharkey soils. Thesis, Louisiana State Univ. Library. 1937.
55. Hoagland, D. R., and Martin, J. C. Absorption of potassium by plants in relation to replaceable, nonreplaceable and soil solution potassium. Soil Sci. 36:1-31. 1933.
56. Hodnett, G. E. Responses of sugar cane to fertilizers. Emp. J. Exp. Agr. 24:1-19. 1956.
57. Holmes, R. L. A study of the use of chemical methods as a means of evaluating the fertility of Louisiana cane soils. Thesis, Louisiana State Univ. Library. 1937.
58. _____. Preliminary studies on the correlation of cane juice analyses and soil analyses. Proc. Int. Soc. Sug. Cane Tech. 6:314-319. 1939.

59. _____, and Hurst, L. A. Comparison of soil analysis with response to fertilization. Proc. 6th Congr. Int. Soc. Sug. Cane Tech. 640-650. 1938.
60. Holmes, R. S., and Hearn, W. E. Chemical and physical properties of some of the important alluvial soils of the Mississippi drainage basin. USDA Tech. Bull. 833. 1942.
61. Humbert, R. P. Basic problems in sugar cane nutrition. II. Applying basic data to sugar cane fertilization. Proc. 8th Congr. Int. Soc. Sug. Cane Tech. 71-79. 1953.
62. _____. Field experimentation to correlate soil and plant analysis with yields of cane and sugar. Hawn. Planters' Record. 55:129. 1955.
63. _____. Potassium Symposium. International Potash Institute, Berne. 1958.
64. _____. The Growing of Sugar Cane. Elsevier Publ. Co., N. Y. 1963.
65. Hurst, L. A., and Holmes, R. L. Soil fertility and fertilizer studies with sugar cane in Louisiana. Proc. 6th Congr. Int. Soc. Sug. Cane Tech. 304-314. 1938.
66. Innes, R. F. The potash manuring of sugar cane. Proc. 10th Congr. Int. Soc. Sug. Cane Tech. 441-450. 1959.
67. _____, and Chinley, T. The effects of fertilizers on sugar cane. I. Potash. Proc. Brit. W. Ind. Sug. Tech. 56-72. 1951.
68. Jack, R. C. M. Nutrient imbalance in sugar cane as revealed by foliar analysis. Trop. Agr. Trinidad. 38(3):231-233. 1961.
69. Jackson, M. L. Soil Chemical Analysis. Prentice-Hall, Inc., Englewood Cliffs, N. J. 1958.
70. Jenny, H., and Overstreet, R. Cation interchange between plant roots and soil colloids. Soil Sci. 47:257-272. 1939.
71. Joffe, J. S., and Kolodny, L. Fixation of potassium in soils. Soil Sci. Soc. Am. Proc. 1:187-192. 1936.
72. Kelley, W. P. Cation Exchange in Soils. A. C. S. Monograph No. 109, Reinhold Pub. Corp., N. Y. 1948.
73. Kerr, H. W., and von Stieglitz, C. R. The laboratory determination of soil fertility. Tech. Commun. Bur. Sug. Exp. Sta., Queensland. No. 9. 1938.

74. Lal, G.- Yield of sugar cane in Louisiana as influenced by soil status and climate. Ph.D. Thesis, Louisiana State Univ. Library. 1962.
75. Lawton, K., and Cook, R. L. Potassium in plant nutrition. Adv. in Agron. 6:254-298. 1954.
76. LeClerc, E. L., Leonard, W. H., and Clark, A. G. Field Plot Technique. Burgess Pub. Co., Minneapolis. 1962.
77. Legrand, F., et al. Phosphorus and potassium requirements for growing sugar cane on organic soils in south Florida. Sug. J. 24(1)22-26. 1961.
78. Lintner, J. Summary of some fertilizer effects on sugar cane. Proc. So. Afr. Sug. Tech. Assn. 1939.
79. Locsin, C. L. Potash fertilization on sugar cane at Victorias. Occidental Negros. J. Soil Sci. Soc. Philipp. 2:105-108. 1950.
80. _____, Guillermo, R. J., and Tabayoyong, F. T. Potash fertilization tests on sugar cane in the Victorias district. Sug. News. 32:69-84. 1956.
81. Lundegardh, H. The influence of the soil upon the growth of the plant. Soil Sci. 40:89-101. 1935.
82. _____. Mineral nutrition of plants. Ann. Review of Biochem. 16:503-528. 1947.
83. Lytle, S. A., and Sturgis, M. B. General soil areas and associated soil series groups. Dept. of Agron., Louisiana Agr. Exp. Sta., 1962.
84. Magistad, O. C. The relation between replaceable potassium and field response to potash in Hawaiian soils. Soil Sci. 37:99-103. 1934.
85. Martin, J. P. Symptoms of malnutrition manifested by the sugar cane plant when grown in culture solutions from which certain essential elements are omitted. Hawn. Planters' Record. 38:3-30. 1934.
86. McKaig, N., Jr., and Hurst, L. A. Preliminary chemical studies of four soil types in the Louisiana sugar cane district. Proc. 6th Congr. Int. Soc. Sug. Cane Tech. 296-302. 1938.
87. _____, and _____. Chemical composition of sugar cane juice as affected by fertilizers. USDA Tech. Bull. 754. 1941.
88. Naquin, E. E. Potash at Honokaa. Hawn. Planters' Record. 30:459. 1926.

89. Neidig, R. E., and McDole, G. R. Miscellaneous soil samples and their value. Idaho State Circ. 33:3. 1924.
90. O'Neal, A. M., and Breaux, S. J. Soil fertility investigations, sugar cane district of Louisiana. Louisiana Agr. Exp. Sta. Bull. 222. 1931.
91. _____, and Hurst, L. A. Methods used to determine the fertilizer requirement of sugar cane in Louisiana. Proc. 5th Congr. Int. Soc. Sug. Cane Tech. 1935.
92. _____, _____, and Breaux, S. J. Fertilizer requirements of sugar cane of Yazoo very fine sandy loam in Louisiana. J. Am. Soc. Agron. 24:888-898. 1932.
93. _____, Schreiner, O., and Hurst, L. A. Fertilizer studies of Yazoo and Lintonia soils, two important sugar cane soils in Louisiana. Proc. 5th Congr. Int. Soc. Sug. Cane Tech. 644-653. 1935.
94. Page, J. B., and Baver, L. D. Ionic size in relation to fixation of cations by colloidal clay. Soil Sci. Soc. Am. Proc. 4:150-155. 1939.
95. Patrick, W. H., Jr. Modification of a method of particle size analysis. Soil Sci. Soc. Am. Proc. 11:366. 1958.
96. _____, and Sturgis, M. B. The effects of other basic ions on the absorption of potassium by white clover. Assn. of So. Agr. Workers Proc. 49th Ann. Convention. 46. Feb., 1952.
97. Peech, M. Diagnostic Techniques for Soils and Crops. The Am. Potash Institute, Inc., Wash., D. C. 1948.
98. _____, Alexander, L. T., and Dean, L. A. Methods of soil analysis for soil fertility investigation. USDA Circ. 757. 1947.
99. Peterson, F. Exchangeable potassium in soils as related to rice yields. Thesis, Louisiana State Univ. Library. 1959.
100. Phillippe, M. M., and White, J. L. Acid-soluble potassium and microcline content of the silt fraction of twelve Indiana soils. Soil Sci. Soc. Am. Proc. 16:371. 1952.
101. Phillips, M. W., and Barber, S. A. Estimation of available soil potassium from plant analyses. Agron. J. 51:403-406. 1959.
102. Pierre, W. H., and Bower, C. A. Potassium absorption by plants as affected by cationic relationships. Soil Sci. 55:23-36. 1943.
103. Piper, C. S. Soil and Plant Analysis. Interscience Publishers, Inc., N. Y. 1950.

104. Pratt, P. F. Potassium removal from Iowa soils by greenhouse and laboratory procedures. *Soil Sci.* 72:107. 1951.
105. Reed, J. F., and Sturgis, M. B. Chemical characteristic of the soils of the rice area of Louisiana. *Louisiana Agr. Exp. Sta. Bull.* 307. 1939.
106. Reitemeier, R. F. *Soil.* U. S. Dept. of Agr. Yearbook. U. S. Government Printing Office, Wash., D. C. 1957.
107. Richards, F. J., and Berner, E., Jr. Physiological studies in plant nutrition. XVII. A general survey of the free amino-acids of barley leaves as affected by mineral nutrition, with special reference to potassium supply. *Ann. Botany, N. S.* 18:15-33. 1954.
108. Rouse, D. R., and Bertromson, B. R. Potassium availability in several Indiana soils: its nature and methods of evaluation. *Soil Sci. Soc. Am. Proc.* 14:113. 1950.
109. Russell, E. J. *Soil Conditions and Plant Growth.* Longmans, Green and Co., N. Y. 1950.
110. Saint, S. J. Manurial trials with sugar cane. *Agr. J. Barbados.* 2(4):1-32. 1933.
111. Samuels, G., et al. Influence of fertilizers on sucrose content of sugar cane. *Sug.* 47:49. 1952.
112. _____, and Landrau, P., Jr. The influence of potassium on the yield and sucrose content of sugar cane. *Soil Sci. Soc. Am. Proc.* 19:66-69. 1955.
113. _____, and _____. The sucrose content of sugar cane as influenced by fertilizers. *Sug. News.* 33:380-386. 1957.
114. Saunders, C. J. Annual report of South African Sugar Association. *The So. Afr. Sug. Yearbook.* 67. 1959-60.
115. Sexton, T. A. F. A comparison of several methods of determining soil available potash. *Proc. 8th Congr. Int. Soc. Sug. Cane Tech.* 124-131. 1953.
116. Shuker, G. W. A study of the physical properties of some of the soils in the sugar cane area of Louisiana. Unpublished Ph.D. Thesis, Louisiana State Univ. 1956.
117. Silva, J. A., Darroch, J. G., and Humbert, R. R. Economic evaluation of yield responses of sugar cane as a function of soil potassium and of supplemental potash. *Soil Sci.* 90:178-184. 1960.

118. Singh, J. N., and Lal, K. N. Absorption and accumulation of potassium in component parts of sugar cane as affected by age, phosphorus deficiency and phosphorus fertilization. *Soil Sci. and Plant Nutrition (Japan)*. 7(4):139-145. 1961.
119. Smith, A. M. Sugar cane fertilizer experiments and recommendations in the Victorias milling district. *Philippines J. Soil Sci. Soc. Philipp*. 3:258-262. 1951.
120. Snedecor, G. W. *Statistical Methods*. Iowa State College Press, Ames, Iowa. 1946.
121. Spurway, C. H. *Soil testing: A practical system of soil diagnosis*. Michigan Agr. Exp. Sta. Tech. Bull. 132. 1933.
122. Stevens, F. D. Agronomic phases sugar cane investigation. Report Florida Agr. Exp. Sta. 185. 1933.
123. Stewart, E. H., and Volk, N. J. Relation between potash in soils and that extracted by plants. *Soil Sci*. 61:125-129. 1946.
124. Sturgis, M. B. More fertilizer needed for crop yields and maintaining soil fertility. *Louisiana Agr*. 4(4). Summer, 1961.
125. _____, and Byrnside, D. S., Jr. Summary of ten years' work with complete fertilizers on sugar cane. *Sug. J*. 1954.
126. Toth, S. J., Prince, A. L., Wallace, A., and Middelsen, D. S. Rapid quantitative determination of eight mineral elements in plant tissue by a systemic procedure involving use of a flame photometer. *Soil Sci*. 66:6. 1948.
127. Truog, E. *Mineral Nutrition of Plants*. The University of Wisconsin Press. 1951.
128. Ulrich, A. *Plant Testing*. The American Potash Institute, Inc., Wash., D. C. 1962.
129. Vallance, L. G. The importance of correct fertilizing. *Cane Growers' Quart. Bull*. 16(1):10-12. 1952.
130. Venema, K. C. W. Potash deficiency symptoms on sugar cane. *Trop. Abstr*. 13(6):408. 1958.
131. Verret, J. A. Potash fertilization gives consistent gains at Onomea. *Hawn. Planters' Record*. 23:208. 1920.
132. _____. The effect of phosphoric acid and potash on the quality of cane juices. *Hawn. Planters' Record*. 27:117-121. 1923.

133. Volk, N. J. The fixation of potash in difficult available form in soils. *Soil Sci.* 37:267-287. 1934.
134. _____, and Truog, E. A rapid chemical method for determining the readily available potash of soils. *J. Am. Soc. Agron.* 26:537-546. 1934.
135. von Stieglitz, C. R. Soil fertility surveys with particular reference to the Garradunga area in north Queensland. *Proc. Queensland Sug. Cane Tech.* 127-134. 1946-1948.
136. Walker, B. The effect of soil type on the response of sugar cane to potash fertilizer in British Guiana. *Potash Review.* 27. 1961.
137. Walker, J. M., and Barber, S. A. Ion uptake by living plant roots, *Sci.* 133:881-882. 1961.
138. Walker, R. K. The effects of fertilizer treatments, drying, heating and wetting on the solubility and availability of potassium in soils. Thesis, Louisiana State Univ. Library. 1941.
139. _____, and Sturgis, M. B. Soil fertility studies. *Sug. J.* 11(6):28. 1948.
140. Worsham, W. E., and Sturgis, M. B. Factors affecting the availability of potassium in soils of the lower Mississippi deltas. *Soil Sci. Soc. Am. Proc.* 6:342-347. 1941.
141. Wyatt, R., and Patrick, W. H., Jr. Chemical and physical properties of the plow layers of three soil series in the sugar cane area of Louisiana. Mimeograph Report, Dept. of Agron., Louisiana State Univ. 1959.

AUTOBIOGRAPHY

Ray Ricaud was born on October 10, 1930 and was reared on a cotton, corn and sugar cane farm in Avoyelles Parish near Moreauville, Louisiana. He was graduated at Moreauville High School in 1948 and received a Bachelor of Science degree in Agronomy at Louisiana State University in 1953. He entered the United States Air Force in 1953 and was honorably discharged as a First Lieutenant in 1955.

He was employed by the Louisiana Agricultural Extension Service in 1955 and in fall of the same year entered Louisiana State University to begin graduate work in Agronomy. He was employed as a research assistant in the Soil Testing Laboratory while in graduate school. He received a Master of Science degree in Agronomy in August, 1957.

After working as a chemist in industry for a short period of time, he was appointed to the rank of Instructor in Agronomy in 1958. He transferred to the Soil Fertility Project with sugar cane in 1961 and is presently in that position.

He is now a candidate for the Doctor of Philosophy degree in the Department of Agronomy, Louisiana State University.

EXAMINATION AND THESIS REPORT

Candidate: Ray Ricaud

Major Field: Agronomy

Title of Thesis: Potassium in Soils Planted to Sugar Cane and Response to Fertilizer Potassium.

Approved:

M. B. Sturgis

Major Professor and Chairman

Max Goodrich

Dean of the Graduate School

EXAMINING COMMITTEE:

J. R. Forbes

W. H. Willis

M. T. Henderson

Wm. H. Hatt

Russell Miller

A. G. Caldwell

Date of Examination:

July 13, 1964